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ABSTRACT

Designed for student use in "Codes, Legalities, Consumerism, and Economics," one of 11 courses in a 2-year associate degree program in solar technology, this manual provides readings, bibliographies, and illustrations for seven course modules. The manual, which corresponds to an instructor guide for the same course, contains the following modules: (1) Consumerism, which discusses the solar potential, solar consumerism, marketing, and the role of secondary sectors; (2) Economics, which considers the economic efficiency of solar energy systems, supply and demand, converting costs and savings to equivalent base, cash flow components, and cost evaluation methods; (3) Public Utility Interfacing, which looks at the role of utilities in solar energy commercialization, rates and costs, and state and federal regulations and controls; (4) Financial Issues, which covers areas such as credit, consumers' cash flow, types of loans, financial institutions, lender concerns, and government incentives; (5) Legalities, which examines legal considerations related to solar access, land use, insurance, and labor practices; (6) Building Codes, Standards, and Warranties, which discusses impediments to solar energy systems, minimum property standards, and types and legal aspects of warranties; and (7) The Contracting System, which focuses on consumer issues, contractor issues, and their interrelationship. (AYC)

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SOLAR ENERGY

CODES, LEGALITIES, CONSUMERISM AND ECONOMICS

Student Material

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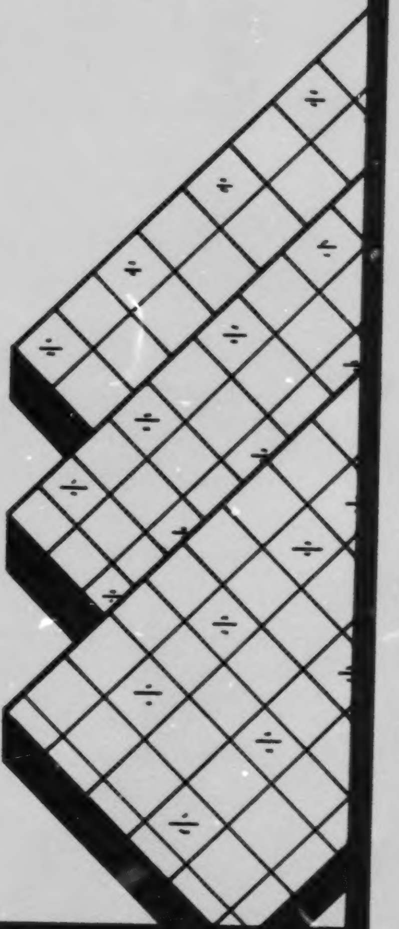

NAVARRO COLLEGE
CORSICANA, TEXAS

Student Material

CODES, LEGALITIES,
CONSUMERISM
AND ECONOMICS

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CODES, LEGALITIES, CONSUMERISM AND ECONOMICS
Student Material

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PREFACE

The United States is facing one of its most challenging decades in recent history. Fuel supply and inflationary prices have forced us to consider alternate energy sources as a means of preserving our standard of living, industrial society, and economic stability. One such alternative is solar.

Presently, foreign crude oil provides the raw material for about one-half the liquid fuel production in the U.S. Political instability in foreign oil-producing countries underscores the need to decrease our ever-growing dependency on foreign energy sources and to lessen our vulnerability to such imports. Solar energy as an alternate can be used as a renewable domestic energy source and to supplement our increasing appetite for oil.

To help bring about the potential for solar energy, there must be a cadre of trained technicians to design, install, troubleshoot, and market solar energy so that the consumer can feel comfortable in the market's ability to service and react to his/her solar energy needs.

With the support of the National Science Foundation, Navarro College, in consortium with North Lake College, Brevard Community College, Cerro Coso Community College, and Malaspina College, has developed and pilot tested a two-year associate degree curriculum to train solar technicians. It can be duplicated or replicated by other educational institutions for their training needs.

The two-year technician program prepares a person to:

1) apply knowledge to science and mathematics extensively and render direct technical assistance to scientists and engineers engaged in solar energy research and experimentation;

2) design, plan, supervise, and assist in installation of both simple and complex solar systems and solar control devices;

3) supervise. or execute, the operation, maintenance and repair of simple and complex solar systems and solar control systems;

4) design, plan, and estimate costs as a field representative or salesperson for a manufacturer or distributor of solar equipment;

5) prepare or interpret drawings and sketches and write specifications or procedures for work related to solar systems; and

6) work with and communicate with both the public and other employees regarding the entire field of solar energy.

This curriculum consists of nine volumes:

1) an Instructor's Guide for the eleven solar courses, to include references, educational objectives, transparency masters, pre-tests and post-tests, and representative student labs;

2) an Implementation Guide addressing equipment, commitment, and elements to be considered before setting up a solar program;

3) Student Material for each of seven of the core solar courses:
    a) Materials, Materials Handling, and Fabrication Processes;
    b) Sizing, Design, and Retrofit;
    c) Collectors and Energy Storage;
    d) Non-Residential Applications;
    e) Energy Conservation and Passive Design;
    f) Codes, Legalities, Consumerism, and Economics;
    g) Operational Diagnosis.

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USE OF THE STUDENT MATERIALS

The intent of this manual is for student use as a supplement to the instructor's guide for the same course. It contains readings, exercises, worksheets, bibliographies, and illustratons to reinforce the concepts contained within this particular course of study. Each student materials manual is written in a similar format but differs in some details due to the nature of the course and the subject matter covered.

Pretests, posttests, and lab exercise are not contained in this manual. Refer to the instructor's guide for this course to find these items.

Student materials manuals are supplied for seven of the eleven solar courses in this project. The four not included are: Introduction to Solar Energy, Energy Science I, Energy Science II, and the Practicum.

The pagination code is used as follows:

I -- the Roman numeral coordinates with the Roman numeral of the instructor's guide.

S -- the "S" signifies that the page is from the Student Material.

5 -- the Arabic number reflects the specific page within this manual, numbered sequentially throughout.

CODES, LEGALITIES, CONSUMERISM AND ECONOMICS

CONSUMERISM

STUDENT MATERIAL

CONSUMERISM

THE SOLAR POTENTIAL

Economic analysis of solar energy applications have indicated that within 3 to 5 years it should be possible to construct systems capable of supplying all of the heating and hot water requirements of large buildings at prices which would be competitive with conventional electric heating. The systems would be competitive if an investment tax credit was granted to the solar equipment.

Electricity used in residences and commercial facilities for lighting, television sets, dishwashers, and other appliances is expected to represent about 9% of the primary energy consumed in the United States in 1985. Residences and commercial buildings pay the highest rates for electricity since these rates must include charges for the costly equipment needed to distribute the electricity to a large number of small consumers. It is likely, therefore, that devices for generating electricity from sunlight will find their first large markets in this sector. (Solar Electric devices will find substantial markets in remote military outposts, signalling devices, and other installations before the large residential market can be approached. The market for systems in remote areas could, however, amount to several hundred millions of dollars of annual sales, particularly if markets in nonindustrial countries can be captured.) Within 10 to 15 years it may be possible to develop onsite solar devices capable of producing electricity for $0.04 to $0.10 per kWh, rates which may be competitive with the cost of electiricy delivered to residential and commercial customers from new utility generating plants.

There is also a potentially large market for direct solar energy equipment in industry and agriculture. Analysis indicates that 2 to 7% of U.S. energy is consumed in these sectors at temperatures below the boiling point of water, and 7 to 13% is consumed at temperatures below 350°F. Solar equipment is now available which can easily provide fluids or direct heating at these temperatures. In many ways, industrial and agricultural markets are more attractive than the residential and commercial markets since the residential and commercial customers are much more diverse and will probably require a more complex and expensive infrastructure for sales and installation. The larger customers are also likely to be confronted with gas curtailments during the next decade and will be in the process of selecting a replacement for natural gas.

There are, however, several major obstacles to solar use in industry and agriculture. Consumers in these categories can use a variety of different conventional fuels (many can burn coal directly) and pay much less for electricity than residential and commercial customers. Moreover, they typically expect payback times on the order of 1 to 3 years for investments in new plant equipment. The cost of industrial solar heat can also be somewhat higher than solar heat provided for homes and residences if it is necessary to install collectors in fields where land, footings, and other aspects of site preparation must be charged to the solar equipment and where piping heat to the factory can be expensive. Smaller installations can be supported by building roofs and heat is generated close to the site where the energy is used.

Analysis of the cost of providing electricity and process heat to a large three-shift industry from different kinds of energy equipment which began operating in 1985 indicated that direct solar heat for low-temperature applications would be competitive with oil if it was assumed that oil prices increase to \$15 to \$20 per barrel by the year 2000 and if the solar equipment is financed by a private utility. Solar heat at temperatures in the range of 350°F was competitive only if it was assumed that oil prices reach \$19 to \$25 per barrel by 1985, and are \$30 to \$40 per barrel by 2000. Competition with natural gas and coal was possible for systems starting in 1985 only if it was assumed that the prices of these fuels increase by a factor of nearly three (from 1976 levels) by the year 2000 (e.g., coal costing \$60 per ton). While such price increases are possible for natural gas, it seems unlikely that coal prices will increase at this rate. It is also possible that solar heat at temperatures below 500°F to 600°F will be competitive with heat derived from synthetic hydrocarbons made from coal.

While most solar heating systems for large industrial or agricultural facilities may not be fully competitive with conventional fuels before the mid-1980's, it will almost certainly be possible to find industries whose specific problems are well suited to the use of solar energy in the near future. There may well be a large near-term market for grain drying systems in less-developed countries, for example. Near-term markets for solar equipment in the industrial sector could also result from existing environmental legislation; solar energy may prove to be an attractive way to expand industrial capacity while minimizing increases in emissions.

Solar cogeneration devices using solar cells or Stirling engines may be attractive in roughly the same circumstances that found solar hot water competitive, although the solar systems were less attractive when compared with cogeneration systems using conventional fuels. It seemed unlikely that solar electric systems which did not cogenerate would be able to compete with the low cost of electricity delivered to industrial facilities from conventional sources until at least the mid-1990's, although unexpected progress in research could well accelerate the rate at which the solar electric systems become competitive.

Solar energy used for direct heat in blast furnaces, glass plants, and other facilities requiring heat at very high temperatures (uses representing 12 to 19% of U.S. energy consumption) are unlikely to be competitive before solar electric systems. Development of an efficient thermochemical process, which could be conducted in a solar collector and reversed in a special burner at high temperature when heat is needed, would greatly imporve the prospects for using direct solar energy in high-temperature applications.

Direct solar energy is unlikely to be used as a substitute for any of the chemical feedstocks which now consume about 3% of U.S. energy. Biomass would clearly seem to be the preferred solar source for feedstocks.

Similarly, transportation, which consumes about 25% of U.S. energy, is unlikely to provide a major near-term market for onsite direct solar energy. There may be some circumstances where electric vehicles could be charged from solar-generated electricity. Development of a thermochemical reaction which yields a portable chemical with a high-energy density would also make "direct" solar transporation a possibility. It is unlikely that the direct solar sources would be preferred to synthetic fuels from biological or other sources.

Considerable caution must be exercised in interpreting statements about the "competiveness" of solar energy systems. First, the benefits of solar equipment can only be realized if the prospective owners compare solar and alternative systems on the basis of life-cycle costing. Life-cycle costs will, in turn, depend on the type of owner since each will have a different tax status, sources of capital, and economic expectations. Solar devices may be owned by the residents of the building, a private corporation, or a municipal or privately owned utility. Each will make different estimates of the advantages of the solar investment. Whether prospective solar customers will actually employ such a procedure is difficult to anticipate and will depend to some extent on the skill with which the solar equipment is sold.

It is difficult to establish a fair basis for computing the cost of nonsolar equipment since the performance of nonsolar is likely to improve as the price of conventional energy increases. There is also great variation in the cost of energy around the country; regional differences in energy prices are greater than differences in the amount of sunlight available.

It must be recognized that if onsite solar energy is to make a major impact on the U.S. energy economy by the turn of the century, it will be necessary to find ways of installing solar equipment on existing buildings. This process can be difficult: such intallations are likely to be more expensive than devices attached to new structures, although there is at present no relaible information about the additional costs which could be expected. It is likely that the percentage increase in costs would be smaller in larger buildings.

There may well be situations where it is not possible to retrofit an existing structure with solar equipment. Densely populated urban areas and heavily treed suburbs present particularly difficult problems, and solar energy used at these sites is unlikely to come from onsite systems. Building orientation may present difficulties in some cases, but a roof must have a particularly poor orientation or roof shape to present a major problem for a solar installation.

SOLAR CONSUMERISM

Buying Solar: Every so often it seems, the American people learn about a totally new product in the marketplace. Several years ago, for instance, the hand electronic calculator was but a wink in a businessman's eye. Now, one can walk into almost any retail outlet and purchase one to keep the checking account in balance and to help figure out the income taxes.

Similarly, it wasn't too long ago when stereo systems first came on the marketplace, and Americans heard a totally new language--woofers, tweeters, anti-static devices, distortion levels, etc. To choose properly, consumers had to learn what these terms meant, and then they had to learn how to compare competing products. Because so many Americans took the time and trouble to learn these essentials, stereo manufacturers by and large fought for the consumer's business by selling quality rather than imagery. Two important results occurred-superior products and satisfied customers.

Will solar evolve, as stereo did, into a widespread, beneficial industry? To a great extent, that answer depends upon the American consumer. The more people who take the time and effort to become good buyers, the greater the chance that solar energy will reach its full potential--providing safe, economical energy to millions of American families.

Selling Solar: The solar industry now manufacturers and installs reliable and practical systems that, given tax credits, can pay for themselves within a reasonable period of time. Nevertheless, current sales volume is too low to sustain the industry. Indeed, the most serious problem facing the solar industry today (1982) is simply that it cannot sell enough systems.

The industry critically needs a big enough boost in sales volume right now to set in motion events that will lead to still more volume in the future. Survey research data confirm what solar industry people have known· lack of sales volume is due to misconceptions about solar and a low level of public awareness about domestic hot water systems. In a nutshell, consumers are unaware that solar domestic hot water is a "here and now" technology that can save energy.

A key activity in the area of consumerism is, therefore, to undertake a major generic educational and public awareness program in order to increase the sales volume of solar domestic hot water systems. While the awareness program is essential to improving sales volume, the problems of credibility and consumer assurance must also be addressed.

Solar Consumerism -- Key Recommendations: The results of a 1981 field survey of active solar systems identified the following to be the key recommendations for solar consumerism:

1. Undertake a major generic educational and public awareness program in order to increase the sales volume of solar DHW systems.
2. Develop a low-cost, consumer-oriented performance monitoring device for installation on all future solar DHW systems.
3. Devise better sensing devices to check on the state of the glycol and implement regular servicing programs, including service contracts. For glycol systems already in place, send homeowners a timely reminder notice, perhaps with a service contract proposal.
4. Devise and implement major cost reduction programs now in order to offset the scheduled expiration of Federal tax credits in 1985.
5. Encourage the Solar and HVAC industries to jointly develop solar integrated designs (SID), for heating and cooling, which maximize consumer rates of return (ROI) and permit modular expansion. This effort should be supported with the development of appropriate design aids and applications training.

Solar Consumerism -- Important Recommendations:

The results of a 1981 field survey of active solar systems indicate the following to be important recommendations for solar consumerism:

1. Aim R&D programs to develop second generation products, using new materials, in order to reduce cost sufficiently.
2. Establish training programs for dealers and contractors in areas of sales, application, installation and service, business management and business growth management.

3. Involve electric and gas utilities in solar development, improving consumer confidence and creating new sales when such involvement is economically beneficial to utilities, consumers and the solar industry.

4. Strengthen channels of communication within the industry and with related industries.

5. Promote statewide uniform solar codes, preferably using existing model codes.

6. Seek industry-wide consensus on sizing methodology and installation guidelines.

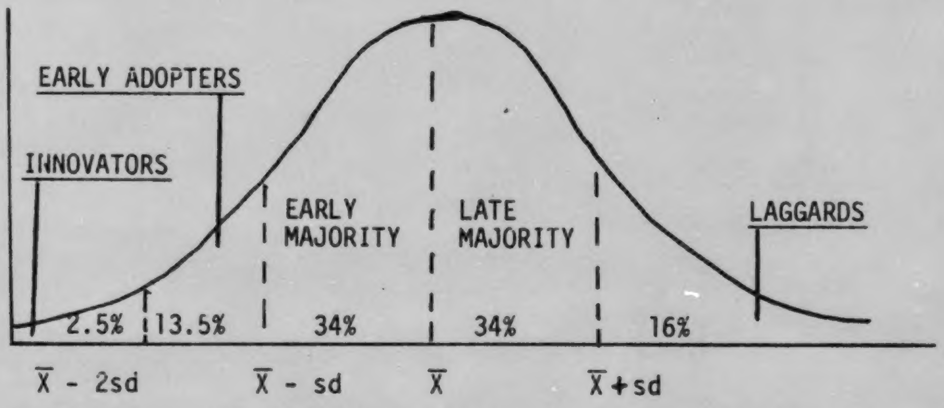
7. Test and certify solar components and systems for performance and durability on a nationwide basis, allowing flexibility for local environmental conditions and technical advances which may alter the configuration of systems.

8. Certify solar installers who demonstrate competence either by extensive experience or by passing a basic contractor's exam with a solar specialty adjunct.

9. Develop long-term financing arrangements appropriate to the needs of the mass market.

Consumer Attitudes. The most serious problem facing the solar industry today is simply that the industry cannot sell enough systems. Dealers, installers, and manufactures in surveys across the country mention this as their number one problem. Solar industry people impute the lack of sales volume to a low level of public awareness about solar energy systems.

The total potential market for any new product may be subdivided into several consumer sectors. "Early innovators" and "early adopters" precede "majority" or mass market buyers, as outlined in the accompanying figure.



Adopter Categorization on the Basis of Innovativeness: The innovativeness dimension, as measured by the time at which an individual adopts an innovation is continuous. However, this variable may be partitioned into five adopter categories by laying off standard deviations from the average time of adoption.

Early innovators buy a new product for the thrill of being first on the bandwagon, or from curiosity. Early adopters buy later than the innovators, but before the larger mass market. Early adopters are symbol show-offs, and more future oriented than the mass of buyers which a product will eventually reach. Data provided by manufacturers of solar equipment in field surveys indicates that the industry, in 1980, has only attracted the "early adopters" and has yet to penetrate the mass market.

From the contractors in New England to the Manager of the Energy Unit for the California Department of Consumer Affairs, almost everyone categorized the average present day consumer as a college graduate, in the upper income brackets, with some engineering, scientific or technical expertise. Over 75% (and in some places as high as 95%) of all those who have bought retrofit DHW systems over the past five years have paid cash.

Consumers as a whole, however, are not convinced that solar can and will work for them. They have heard about the problems with solar systems in recent years, and would prefer to let other homeowners play "guinea pig" with a new energy-saving device.

Marketing

Active Solar Industry: The active solar industry is currently developing from a base in swimming pool heaters and the domestic hot water market. Much of the industry is characterized by relatively small, undercapitalized firms, often staffed by young, enthusiastic, but inexperienced and untrained businessmen. The industry is realatively easy to enter. Statistics indicate that the industry had a major growth period in the mid-70's, when many new firms entered the market. Exit rate is also high; a number of factors contribute to the rate of business failure. The inordinately large number of firms competing in a limited market keeps profits per firm low, restricting the resources any one firm can invest in further developing and promoting solar technology. Skilled businessmen are essential to growth.

Although the market for solar products is fairly clear and well-defined, the industry itself is not. It is nearly impossible to define the "solar industry" to the satisfaction of all concerned. The Energy Information Administration (EIA) uses a narrow description to generate working statistics, including in the industry, "all companies that manufacture solar energy collectors, and/or companies that are importers of solar energy collectors". This definition excludes the non-manufacturing sectors of the industry, and those whose businesses may be only partially dependent on solar-related revenue. However, such businesses as component manufacturers, distributors, delaers, installers, builders, architect/engineers, and those who perform basic research and development consider themselves very much a part of the solar industry. The EIA definition does cover those businesses primarily dependent on the newest and only exclusively solar component of active systems, the collector. EIA statistics therefore, provide a basis for comparison in charting the development of the active solar industry.

Between 1974 and 1979, the number of solar collector manufacturers making medium temperature collectors (i.e., collectors suitable for domestic hot water and space heating) increased from 39 to 226. Sales revenues expanded at the same time from $1.5 million in 1974 to $65.4 million in 1979. The most dramatic growth took place in 1975-77, leveling off significantly in 1978 and 1979. The growth rate, while it reflects a substantial increase in demand for alternate energy sources during that period, also suggests that the solar market is relatively easy to enter. Most firms, even after the major growth period, were still very small, suggesting that they remain low capital ventures. Published research confirms that solar businesses, because they are new ventures, have minimal capitalization and employ only a small number per firm.

The rate of market exit is also high, reflecting the difficulty of surviving as a new and undercapitalized firm in a volatile market. One industry observer in Florida estimated a 25-50% annual turnover rate in that state. Another study of the San Francisco area estimated that one-third of the local solar manufacturers leave the market each year. An architect/engineer in northern California also indicated that the turnover among dealers was equally high and went further to suggest that an interested consumer should compare phone book listings to find a good dealer. Any firm listed in two consecutive years could be considered as good a bet as one can find.

Solar Entrepreneurs: A brief character profile of solar entrepreneurs hints at the reason solar thermal technology has developed to its present position in spite of the obstacles. The latest edition of the Solar Energy Source Book, published by the Solar Energy Institute of America, includes company profiles which give a composite picture of the solar entrepreneur. Company listings indicate that a significant portion of the industry is made up of private individuals who have incorporated themselves and begun to make collectors. Many of the solar companies have founders with backgrounds ranging from undergraduate study in anthropology to careers in the military. Many had technical and scientific aptitude, but few had years of hands-on trade experience, and fewer still had business training. The small companies often lack such essentials as printed catalogues, installation guidelines, and service arrangements.

These same profiles, however, suggest that solar entrepreneurs are highly committed to solar as an energy source, and are extremely enthusiastic, maybe even over-enthusiastic, about increasing its marketability. One new business in Connecticut, for example, which had as yet no installations to its credit, and no manufacturing plant, claimed a production capacity of 500 units/month, and was working to establish an international market. Another company had produced only 3 units, but claimed production capacity of "500/year ++", as well as "worldwide" distribution. A number of such new enthusiasts are profiled in the Source Book. This type of dedication and determination alone may assure a continued place for solar in the energy market.

On the other hand, many solar businessmen combine enthusiasm with solid business expertise. In recent surveys, one businessman had a particularly well-developed marketing program; another exhibited involvement with product research and development efforts. Several businesses were moving toward distribution arrangements, and some were pursuing well-designed cost reduction strategies. These businesses are much better equipped to effectively market and service their products, and suggest the presence in the industry of growing business skill. The combination of the enthusiasm of new businesses with the increasing business sophistication of older ventures gives an optimistic outlook about the long-term future of the industry.

It can generally be concluded that at this time the solar industry is developing in a normal and healthy manner, as compared with the heat pump and other new industries. It can continue to grow, based on the commitment and increasingly seasoned business judgement of solar business people.

Industry Credibility: The active solar industry can penetrate the space heating market from a rapidly maturing industry based on the domestic hot water market. The DHW industry now manuractures and installs reliable and practical systems that are cost effective. The industry still has cost and quality problems, but most of these could be solved, if sales volume were high enought. Unfortunately, sales volume is not high enough. Indeed, the industry critically needs a big enough boost in volume right now to set in motion events that will lead to still more volume in the future. This can happen, but only if an awareness campaign is mounted which will educate the public specifically about solar DHW as a generic product.

Assuming such a generic campaign is mounted, a number of other things must be done to help solar DHW increase its volume of sales to reach the mass market, first in hot water heating, and then in space heating. In order to build industry credibility and reassure consumers, system performance must be monitored, utilities involved, codes and standards improved, delaers licensed and installers certified. In order to make solar affordable to the mass market, long-term financing must be offered and costs radically reduced. All of these efforts take time--which means that they must get started as soon as possible.

There are virtually no adequate solar installer certification or contractor licensing procedures. The solar industry and solar contractors are unanimous in stating the need for certification for installers. Both groups feel that proper testing of skills or knowledge prior to certification would lead to better installations. It would also provide a minimum level of consumer assurance.

Proper testing and certification of solar installers is a high priority action on the part of states. Proper testing of other appropriate contractor license categories for supplementary solar adjunct is also necessary. It would be appropirate for the private sector to develop a consensus certification requirment to provide to states as a model for adoption. A solar license should allow the solar contractor to connect a potable water piping to the tank.

The Secondary Sectors

Utilities: Given the twin facts that (1) potential buyers of solar DHW equipment must consider a system that costs $3000-4000, perhaps the third largest expenditure they will ever make, and (2) DHW dealers and manufacturers are relatively new--it's no wonder that consumers need some kind of assurance before they take the plunge. What's needed at this stage is a recognized, reputable institution not only to promote solar technology, but to loan solar the credibility in local markets which, by itself, it cannot yet inspire. The utilities may be the appropriate institution.

There are advantages for the utility in participating, as well as for the solar industry. The increasing use of solar energy for DHW not only decreases the need for direct or indirect burning of fossil fuels, but also frequently results in a shift in energy type used for back-up or supplementary purposes. As an example, a house formerly served with DHW from an oil-fired space heating boiler may be converted to a solar system supplemented by electricity or natural gas. Thus, the gas or electric utility has a new load imposed upon its system which does not conform to its historic water heating load patterns. Whether the growth of these new load shapes has a positive or negative economic effect on the utility may reasonably be under the control of the utility.

An east coast electric company is an example of active utility participation in solar water heating. Through its own promotion and working through local HVAC and plumbing contractors, the utility sold approximately 600 solar DHW systems over a two year period. Each system was provided with electric supplement supplied on a time-of-day basis at a reduced rate. The availability of electrical supply to the water heating elements is completely restricted to the period between midnight and 7:00 A.M. daily. This time period is governed by a time-of-day meter and a relay supplied by the company. The meter and relay measure and control only the water heater circuit. Storage capacity for hot water is sized to compensate for the supplemental heating restrictions. Tank sizes are 82 to 120 gallons. A simplified performance monitoring system is contained in each installation. Each customer provides monthly data to the utility by mail.

Through this pilot program, the utility has gained knowledge of system quality, performance and sizing optimization. Most importantly, it has learned the extent to which new loads and load shapes will impact on the economics of their business. These new loads have been added under conditions which economically benefit both the utility and its customers. The utility is assured on only nighttime loads and the customers receive a lower electrical rate for water heating.

However, the above example is an exception to the general situation. For the most part, there is a general lack of communication between utilities and the solar DHW industry both on a national and local basis. This can have a potential negative economic effect on the utility, the solar dealer and the customer. For example, a customer in the Northeast was planning to install solar DHW. At the same time, the local electric utility was preparing to inaugurate lower time-of-day electric rates. Neither the consumer nor the solar installer knew of the utility company's plan, so the DHW system was not designed with a hot water tank big enough to take advantage of the new nightime rate. Better communication would have avoided adding demand to the utility's peak, secured the solar dealer a more enthusiastic customer, and would save the customer more money.

Recommendations to the electric and gas utility industries, both on a national and local basis, would include the following:

1. Establish communications with the solar industry including manufacturers, wholesalers, and dealers.

2. Be alert to the need for communicating with the solar industry in matters, such as policy or new rates which may alter the design or cost effectiveness of solar systems.

3. Make available to the solar industry and especially to their suppliers of DHW controls, the utility's methods of controlling off-peak, time-of-day, usage.

4. Determine the economic effects for the utility and its customers where solar is applied to various system concepts for water heating, space heating, and space cooling.

5. Provide solar energy information and sponsor training to buying influences such as builders, architects, and engineers.

6. Help create consumer awareness by incorporating state-of-the-art solar data in such activities as speaker's bureaus and consumer advertising.

The solar industry is young. Its customers and sales prospects need the reassurance which can be provided by local, more established industries such as electric and gas utilities. It would be highly desirable if the common ground between the utilities and the solar energy industry could be promptly identified and explored, especially in the areas of load management and marketing. Local action, because of variations in utility policies and rates, is especially advocated.

The adoption of such recommendations could provide both the utility and the fledgling solar industry with sound economic growth. Most importantly, economic benefits could also be provided to their mutual customers.

Financing: Even with substantial cost reduction, and improved consumer confidence, solar will not necessarily attract mass market consumers. The mass market will have to purchase solar systems on credit, and therefore, long-term financing is essential if solar is to penetrate that market. Financing a system has not yet become a problem because the early adopters can afford to pay cash for their domestic hot water systems. And the early adopters are not overly concerned about payback times and positive cash flows. Not so the mass market. Most buyers in this market will need some kind of financing arrrangement that will generate a positive cash flow almost immediately.

Although there are a few contractors and builders who are designing innovative finance plans, the only generally available financing at present seems to be normal bank loans for home improvements, and these at high interest rates for relatively short time periods, e.g., 7 years. This is just short of what is needed to be attractive to the mass market. An attractive financing plan for the mass market would have to generate a positive cash flow by the end of the first year. Ideally, the homeowner's finance payments should be less than the amount of money he used to spend to heat his hot water. Based on calculations by the Institute of Public Administration, it appears that a 10 year financing plan, at 15% interest, would generate a positive cash flow starting with the first year on a solar DHW system costing $2000 net after tax credits (conclusions drawn from calculations made in February 1981).

The Institute of Public Administration calculations used the severe weather conditions of the Northeast, where water is heated mainly with oil, but the caluclations have a more general relation to the overall situation. First, the calculation indicates that the appropriate loan period for a solar system is somewhat longer than for other home improvements, requiring a 10 year rather than a 7 year limit. Second, assuming the loan period for solar DHW can be extended to 10 years, the government could reasonable expect commercial lending institutions to handle the financing, obviating the need for a program of low cost solar loans to homeowners.

Codes and Standards: Specific system and component assurance must be provided through the development of appropriate codes, standards and certification programs. There are over 22 different organizations which have or are preparing solar codes and standards documents. This plethora of proposed codes has caused confusion within the solar industry and, more importantly, within local government code enforcement agencies. As a result, different codes and methods of enforcement may be present in a relatively small geographic area such as the Denver metropolitan area.

There appears to be a consensus among Code officials and the solar industry that a manual, such as the "Solar Systems Code Review Manual", published by the International Conference of Code Officians (ICBO), would form the basis for permit approval. This approach is preferred to the adoption of a model solar code. The advantages lie in the fact that code officials and the private sector are generally familiar with existing model codes for which there is broad consensus. The ICBO "Solar Code Review Manual" or a similar manual should be distributed widely to local government officials, industry trade organizations, and industries. Training in the manual's use would be appropriate for potential users to ensure uniformity of interpretation and application. The primary responsibility for distribution, training and enforcement should be placed on state governments.

A consensus has not yet been reached on what constitutes a properly sized solar system. California is likely to have state-wide sizing guidelines shortly. A need exists, however, for a sizing standard which takes into account such variables as local climatic conditions, the generic solar systems to be used, the load size, and system performance. A comparable problem existed years ago in the HVAC industry. It was solved by the industry, the trade associations, and its professional societies by adopting uniform, flexible standards and methods. These standards and methods would then be available for use throughout the solar industry and by code officials.

ECONOMICS

Is solar a good investment for you, the consumer? The question is simple, the answer is complex. To know why, one might compare buying solar with buying a house as opposed to renting one. When you buy a house, you slowly but surely gain ownership. When the day finally comes that you pay your last mortgage payment, it's all yours. No more payments. If you have to sell before you make the last installment, you certainly won't lose much from your investment and, in fact, you probably will receive more for your home than you paid for it while saving on tax deductions. But to realize a return or a profit on your investment, you will have to undertake regular maintenance and repair activities. If you rent, you don't have to worry about maintenance and repair, but when it comes time to move, all those rental dollars are lost forever.

Buying solar is somewhat the same, but with a few important differences. When you buy a solar system, you are concerned about initial and lifetime costs. There are today some new home builders who claim that costs for their residences with hybrid or passive solar systems are close to prices for comparable homes with conventional heating and cooling systems If these systems function properly, then the consumer can expect a very short payback period--that is, the time needed when the savings from using solar energy will pay for the extra costs of the system.

If you are going to buy an active system, however, your initial costs will be much larger than the price for a conventional system, and your payback period will be much longer. You will in a sense be paying for several years' supply of energy all at once. As with passive systems, you will have to be concerned about durability. Maintenance and repair costs will add to the time needed to pay back on the system. But when the solar system is paid for, you will have free energy coming into your home. If you relied on a conventional system, it would be like renting--no hope of ever regaining the dollars spent for the operation of a conventional system.

However, as with renting a home, renting or leasing a solar system may provide you with some advantages. If, for instance, you were offered the rental of a solar system for $25 a month, repairs and maintenance included, with an estimate that it would save you $40 a month in utility costs, then you could come out ahead by $15 a month or $180 a year if the projections were correct. You would never own the system, but you would obtain some savings with no repair or maintenance problems to worry about.

There are times when a solar system is not a smart purchase, when conventional systems are a better buy. You may find that initial costs are prohibitive, or that the time period to pay back your investment is too long for your needs. Or that some of the unknowns about solar, such as solar rights and property appreciation or depreciation, are too risky.

Solar heating practitioners concerned mainly with selecting and installing solar heating systems may seldom need economic information other than the costs of equipment and installation labor. However, when it is important to make decisions and provide recommendations for the most economic alternative for heating a building, some form of economic analysis will be necessary. Solar heating systems require higher capital costs than conventional systems, and many economic evaluation methods attempt to determine the relative merits of "paying for hardware" or "paying for energy". One simple method is breakeven analysis, which involves a comparison of unit thermal energy costs delivered by the solar system and a conventional system. A second simple method involves determination of a payback period required to amortize initial investment for solar equipment with savings in cost of conventional energy. A more elaborate analysis, which considers a number of important economic factors during the life of the system, is called life-cycle-cost analysis.

An economic analysis may include some or all of the factors listed below:

- Equipment and installation costs (or, alternatively, periodic mortgage payments)
- Operating Costs
  - Fuel Costs
  - Electrical energy costs for pumps and blowers
- Added property tax on the solar system
- Added insurance premium for coverage
- Maintenance Costs
- Inflation
- Credits
  - Income tax credits and/or deductions based on system costs
  - Investment (for businesses)
  - Income tax credits for interest and added taxes.

The simple economic evaluation methods may require knowledge of only a few of these factors, but life-cycle costing may involve all of them.

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CODES, LEGALITIES, CONSUMERISM AND ECONOMICS

ECONOMICS

STUDENT MATERIAL

CODES, LEGALITIES, CONSUMERISM AND ECONOMICS

ECONOMICS

FUNDAMENTALS OF ECONOMIC EVALUATION

Successful and widespread applications of solar energy for heating of buildings depends ultimately on consumer acceptance. While it is very difficult to predict consumer actions under any given set of circumstances, consumer opinion does tend to be shaped by the prevailing legal, political, social and economic climate. Insofar as solar energy is viewed as an alternate energy source, it must compete with natural gas, oil, coal, hydro, and nuclear.

If nonarbitrary choices are to be made among energy alternatives, these alternatives must be evaluated on a common basis. In a market economy this basis is an energy system's value, which is determined by the interaction of market forces. These market forces include scarcity of resources (both energy and nonenergy) needed for the system, competing uses of the resources, and human needs and desires for the product. A market evaluation of alternative energy options by individuals, households, and firms results in a dollar value being placed on each quantity of energy produced by a given system. Economic considerations are essential for the comparison of technically feasible energy alternatives. Technical aspects of an energy system only determine its technical feasibility. Many products are technically possible, but the existence of alternatives makes this feasibility a moot point. Thus, the evaluation of energy alternatives must include economic considerations rather than only technical or political ones.

An individual faced with a decision of whether or not to install a solar-heating and/or -cooling system would, if his judgment criteria were purely economic, compare the expected rate of return on the solar system with the expected rate of return on alternative investments. If a decision were made strictly on this basis, exogenous factors, such as whether natural gas would continue to be available, whether fossil fuels might be freed for other priorities, or whether the pollutant level in the atmosphere might be reduced, would not have to be taken into account.

Considered as an investment decision, the true worth of an investment depends on how much income it will generate--and how soon--after the original outlay. Other things being equal, investments that generate a large share of total income in the early years of their life are more desirable than those that produce income in later years. The investment returning income sooner provide the investor with money-in-hand that is then available for investment in other income-producing projects.

The net investment in a solar energy system is the net cash outlay one has to make to switch from a certain conventional energy system to a solar energy and auxiliary system. Conceptually, this has to be so even though the switch is hypothetical.

The cash flows (dollar value of energy savings) occurring over the life of the investment are the savings realized by using solar energy. The economically oriented decision maker will thus want to calculate the discounted rate of return on investment and the present worth of the cash flows occurring over the life of the investment. The investment is economically feasible if the present worth of energy savings over the lifetime of the investment exceeds the initital cash outlay.

Economic Efficiency

There are many reasons for the renewed interest in solar energy systems. Resource availability is an important part of this interest. All resources, nonenergy as well as energy, are available only in limited quantities during any given period of time. Because of these limitations, resources need to be used as efficiently as possible. While most people would probably agree with this conclusion, "efficiency" can have widely divergent meanings.

Efficiency has often been defined with reference to a single input. For example, energy efficiency often refers to the technical efficiency of conversion processes: each unit of the energy resource used should produce as much of the desired commodity (electricity, heat, propulsion, etc.) as possible. But such a definition creates problems when there is more than one way to produce a commodity or more than one resource needed for production. Continuing to emphasize only one input is too narrow a definition. Insisting that all rescources should be used in their most technically efficient manner ignores the possibility for trade-offs among inputs.

Possible trade-offs can be illustrated by considering electricity generation from steam. Steam can be produced by a nuclear reaction or by the combustion of coal, natural gas, or oil. Each method of electricity generation has approximately the same technical efficiency (in the 0.3 to 0.4 range). Thus, if they were to be evaluated only on technical efficiency, there would be little basis for choosing among them. Nevertheless, there are good reasons for choosing one method of electricity generation over another. These reasons are largely based on the fuel and capital costs associated with each method, and on the patterns of electric energy usage.

As shown in figure 2-1, the use of electric energy is not uniform over any given day. Daily peak usage typically occurs in the late afternoon and early evening as people return home from their day's activities, turn the thermostat up (in winter) or down (in summer), turn on lights and the television, and begin using their electric appliances to prepare dinner. A similar, but smaller, peak occurs in the morning as people get ready to begin their day's activities.

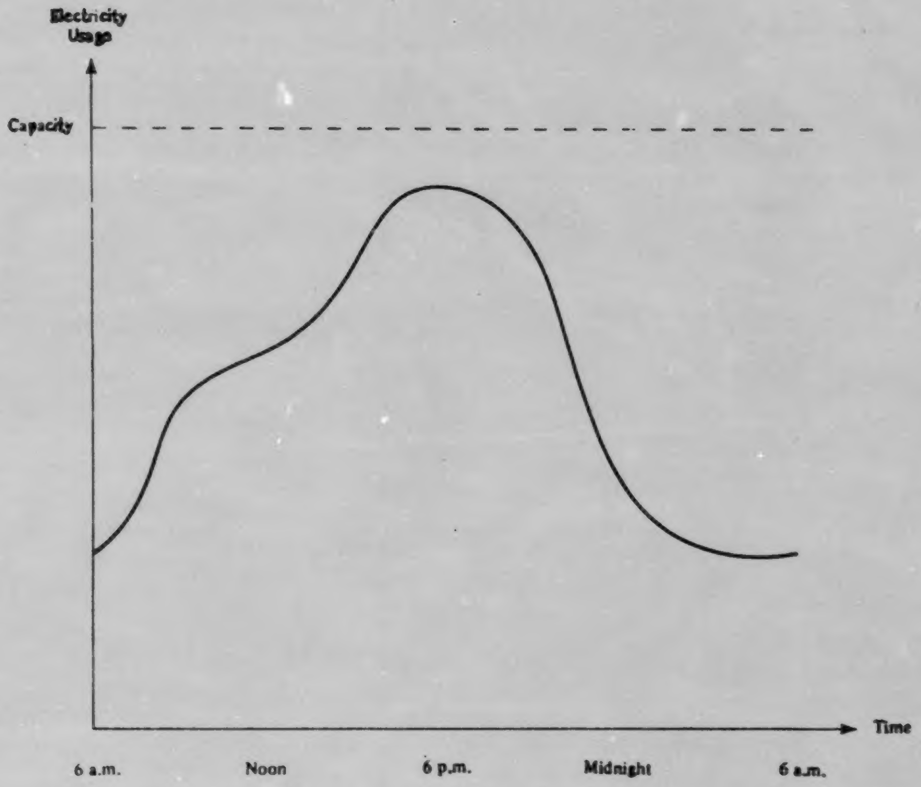


Figure 2-1 A daily pattern of electric energy usage

Electric utilities are required to have enough generating capacity to provide electricity during periods of peak usage. This means that over a significant portion of each day a fraction of their electric generating capacity is idle. The percent of an electric utility's generating capacity in use plotted against the number of hours that capacity is used is called a load-duration curve. The load-duration curve for the electricity use pattern of figure 2-1 is shown in figure 2-2.

It is customary to classify an electric utility's generating capacity according to whether it is used as base, intermediate, or peak load. Capacity providing base load is in almost constant use during any given day. Intermediate load capacity is used a significant portion of each day, whereas peak capacity is used only for short periods of time.

The trade-offs in the generation of electricity depend upon the cost of energy resources, the cost of generation facilities, and the pattern of electricity consumption. Of the energy resources used to produce steam-generated electricity, oil and natural gas are by far the most expensive per kilowatt hour of

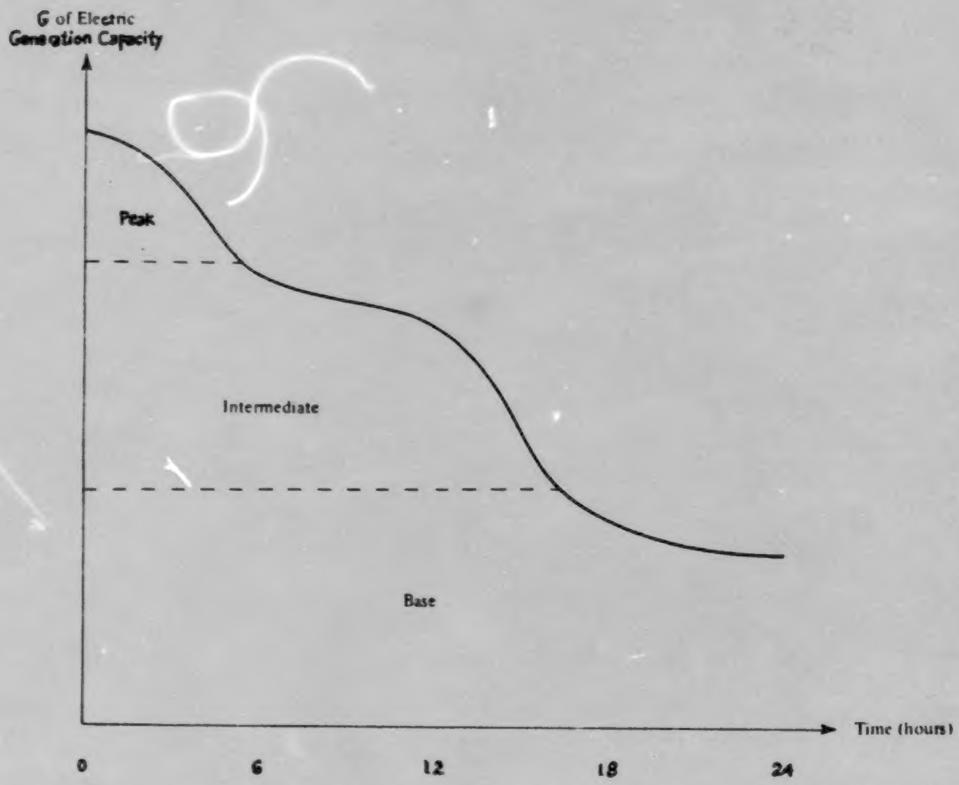


Figure 2-2 An electricity load duration curve

electricity produced. Coal is significantly less expensive than oil and natural gas, but is more costly than nuclear fuel.

On the other hand, a nuclear electricity generation facility is the most expensive per kilowatt of capacity because of the need to contain the nuclear reaction. Fossil fuel facilities are significantly less expensive than nuclear facilities. Although they employ essentially the same conversion process (combustion), coal-fired steam electric generating facilities are more expensive per kilowatt of capacity than are natural gas and oil-fired facilities, primarily owing to the additional pollution-abatement equipment necessary for coal facilities.

Another consideration is the response time associated with each method of generation. It is a relatively lengthy process to bring a nuclear reaction to its designated (and hence technically efficient) steam-generating capacity from a cold start. The fossil fuels produce steam through combustion and can therefore produce steam more quickly than can a nuclear reaction. However, combustion from oil and natural gas is more easily and quickly begun and stopped than is coal combustion.

Nuclear generation investments are profitable only when the initial investment costs may be spread over long periods of continuous generation. Thus, nuclear electric generation capacity is utilized for base loads so that these expensive facilities are in use almost continuously. Coal-fired steam electric generation provides the remaining base-load capacity not provided by nuclear generation. With their lower facility costs and higher fuel costs (compared to nuclear generation), it is less expensive to let them sit idle when there is unneeded capacity. In addition, they can be fired up and shut down more easily and quickly than nuclear reactors. For similar reasons, natural gas and oil-fired steam electric generation provides peak capacity and the intermediate capacity not provided by coal-fired generation.

The trade-offs between initial costs, recurring expenses, and the ability to meet changing demand patterns indicate why different energy sources are chosen for electricity generation. Oil and natural gas are expensive energy sources, but facilities which utilize these fuels to generate electricity are relatively cheap to build and can respond to changing demand conditions more rapidly. These characteristics make oil and gas-fired facilities preferable when supplying peak power and fluctuating loads. Alternatively, coal and nuclear generation serves continuous loads at a lower cost, even though the initial construction cost is greater because fuel costs are lower. Which form of generation is chosen depends upon usage patterns and relative costs, and the trade-offs possible among these characteristics.

Electricity generation from new energy alternatives may eventually become viable if other possible trade-offs among resources are considered. The list of trade-offs would include a wide range of resources--production capacity, energy inputs, the labor required to assemble and maintain the product, and less obvious resources such as the ability of surrounding regions to absorb pollution and the willingness of nearby residents to accept health hazards and risks. To emphasize only one input--be it energy, labor, or anything else--when calculating efficiency ignores the contributions made by other inputs. In the past, a disregard for the regenerative capabilities of air, water, and plants led to high levels of pollution. Concentrating only upon the efficiency of energy usage could lead to similar side effects.

Economic definitions of efficiency allow for trade-offs among resources. An energy system is said to be economically efficient when it achieves its purpose with the least misallocation of resources. Technical efficiency is subsumed by this definition. If the quantities of nonenergy resources used are held constant, consumption of energy resources must be technically efficient to be economically efficient. Furthermore, economic efficiency expilicitly considers trade-offs between the energy and nonenergy resources used, as well as their by-products.

The economic definition of efficiency is important when selecting new energy technologies. Trade-offs among energy and non-energy resources and the value of each of these resources to consumers as well as producers must be considered. Systems that directly utilize solar insolation could become an important energy source. However, currently available systems focus upon the heating and cooling of buildings and require significant amounts of surface area to collect sunlight. Further research and development (R & D) could produce solar technologies that generate higher temperatures, utilize less collector surface, or provide electricity more efficiently in the technical sense. Such new designs could be used by industry and electric utilities. These innovations may be more technically efficient in terms of power output and land usage, but the new systems may also be relatively expensive, have new technology "bugs" that must be resolved and have the safety problems associated with any high-temperature or electric apparatus. These additional considerations will be important aspects of solar technology development.

Besides the trade-offs among solar technologies--higher temperature versus greater safety hazards, widespread industrial use versus more expensive equipment--there is a trade-off between solar technologies and other goods. An intensive government R & D or purchasing program designed to develop and promote solar energy may achieve that goal. But emphasis on solar energy R & D draws technical expertise away from other research efforts, such as food production and medical studies. It also uses up funds that might have gone to programs such as public transportation, crime control, urban redevelopment, or aid to the elderly. Even if a safe, inexpensive solar technology could be developed, it is not entirely clear that the general population could consider a large solar energy program to be the best use of public funds.

Thus an evaluation of solar energy cannot take place in a vacuum. The economic efficiency of a solar technology depends upon the alternatives that are available and the possibilities for trade-offs among these alternatives. Because alternatives and trade-off opportunities are constantly changing, so are the economic efficiencies of solar energy systems.

Cost Concepts

Besides motivating the economically efficient use of resources, scarcity imposes costs on decisions. This is because scarcity --of time, income, or natural resources--forces choices among alternatives. Natural gas used to produce electricity could also have been used for space heating or industrial purposes. These alternatives impose a cost on the use of natural gas for electricity production. No producer or distributor would sell natural gas to an electric utility for less than could be earned by selling gas for its alternative uses. Thus, the minimum cost of a resource is the price it would command in its best alternative use--its opportunity cost.

The economic concept of cost is based upon opportunity cost, not the usual accounting definition of production cost. In fact, opportunity costs may differ significantly from production costs. Although Middle Eastern oil costs less than a dollar per barrel to produce, its opportunity cost is the going international market price. If some oil company or country is not willing to pay that price, many others are. Thus, the minimum price at which a sheik will sell oil to Exxon is the maximum price Texaco is willing to pay.

One consequence of valuing resources at their opportunity cost is that all resources are being used efficiently in an economic sense. If resources are employed in the most valuable alternative use, misallocation of resources is minimized. For example, suppose that electric utilities are willing to pay $1.50 per 1000 cubic feet, homeowners $2.50, and industrial users $2.00 for natural gas. The opportunity cost of natural gas is $2.50 per 1000 cubic feet for electricity generation and industrial usage, and $2.00 per 1000 cubic feet for residential space heating. In this case, the natural gas would be sold to homeowners for $2.50 per 1000 cubic feet. Homeowners are willing to pay the highest price because natural gas is most valuable to them. Thus, natural gas misallocation is minimized.

A second consequence is that a cost is incurred only when someone is denied the use of a resource. Since the quantity of solar radiation one individual uses need not diminish the quantity available to others, it has an opportunity cost of zero. (An exception would be when one person's solar collector shaded that of another.)

Although solar radiation has a zero opportunity cost, there are positive opportunity costs associated with the energy technologies that utilize solar radiation. Many solar advocates argue that large-scale production will reduce the per unit cost of solar modules. They correctly imply that the initial investment is spread over a larger number of units. However, they ignore the costs of some very important inputs whose opportunity costs are increasing.

One of the most important inputs is surface area. Photovoltaics and solar thermal energy require roof space or open land. The first units of solar energy will be inexpensive. Some rooftops or land areas receive large quantities of insolation, but have few alternative uses. However, further increments to solar energy capacity will be more costly. Additional systems may receive less insolation, so more collector area must be used to obtain the same power output as the first units did. If more land is devoted to solar energy production, less acreage is available for housing, recreation, or other nonsolar uses. While the costs of producing one more solar module may be falling, the opportunity costs they place upon land are rising.

Land need not be the only input with rising opportunity costs. If the solar energy industry grows rapidly enough, the primary material inputs--aluminum, plate glass, silicon--will also have increasing opportunity costs. This is not because the input industry is trying to make windfall profits at the expense of energy-conserving solar users. If these inputs can be used elsewhere (e.g., construction, glass containers, solid-state technologies), the rapid growth of solar-energy-related uses means that inputs are being taken away from valuable alternatives.

A second economic cost concept relavant to energy evaluation is marginal cost. This is simply the extra costs that will be incurred by a decision. For example, suppose an electric utility is evaluating how to expand its base load generating capacity. If it intends to build a coal-fired steam facility, the marginal costs relavant to this decision include the costs of the facility, fuel, and operation and maintenance expenses. On the other hand, if the utility is considering shifting a coal-fired steam facility currently used for intermediate load capacity to base load capacity, the relevant marginal costs are only the additional fuel and operation and maintenance expenses incurred by the extra electricity production. The main point is to ignore positive and negative events that would occur anyway (the sunk costs) regardless of what decision is made. Choices should be based on the additional resources used, pollution produced, and risk involved and how these costs compare with additional expected benefits.

These two cost concepts form the basis of economic definitions of cost. The economic costs of a decision are the marginal costs of undertaking that choice, where all resources used are valued at their opportunity cost. Many subtle assumptions are included in this definition. "Resources used" includes environmental, health, and safety effects, as well as materials and labor. Furthermore, "opportunity cost" implicitly assumes that alternatives are being compared under general market conditions. Since market conditions change over time and space, this economic measure of cost fluctuates as rapidly as opportunities. However, it is a better measure of cost than production or acquisition prices, since it reflects existing market conditions and opportunities.

Cost-Effectiveness of Solar Energy Systems

The main steps that would be taken to evaluate the cost-effectiveness of a solar energy system are the following:

1. Identify the alternatives in solar and conventional energy equipment (and in conservation measures) which are to be considered, as well as any constraints that must be met.

2. Select a method of economic evaluation, taking into account the nature of the choice and any special investment considerations.

3. Decide on the basic assumptions and select values for key economic parameters such as the economic lifetime, loan interest rates, discount rate, and present and future energy prices.
4. Specify values for all relevant, significant cash flows associated with each alternative over the designated time horizon.
5. Use discounting techniques appropriate to the selected evaluation method to adjust differently timed cash flows to a comparable basis.
6. Carry out the evaluation method for each alternative to obtain comparative measures of economic performance for each alternative.
7. Select that alternative with the highest economic performance.

SUPPLY AND DEMAND ANALYSIS

Supply and demand analysis is a very powerful method of determining the market value of a commodity. It explicitly recognizes the forces at work in the marketplace--the state of technology, income distribution patterns, tastes and preferences, availability and prices of alternatives. No planning agency is required to determine what is needed, what is producible, and who gets what is produced. Demand and supply interact in many subtle and complex ways to determine the price of a good. This price serves as a signal to all members of the economy. If the price is high, consumers are induced to conserve and seek out substitutes, while firms that could produce the high-priced good are induced to begin or expand production.

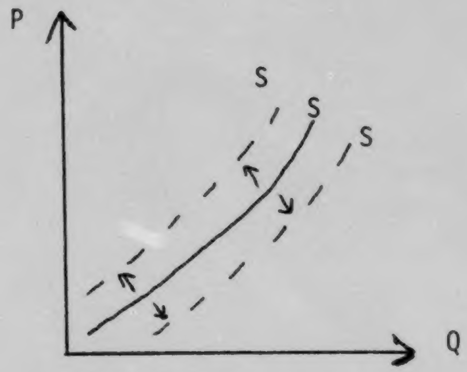
The interaction of supply and demand forms the basis for market value, which can be used to compare and choose energy systems. Choices based on such evaluations will be economically efficient. Furthermore, market value also allows choices to be made among energy and nonenergy resources.

Supply Relationships

Every market for energy has two aspects, production and consumption. The market forces affecting production manifest themselves through supply relationships. Demand represents the wants and needs of consumers. The interaction of these two aspects determines the market value of an energy system.

Economic cost concepts may be used to construct a supply curve, which measures how many units of a commodity producers are willing to provide at any given price. The cost of supplying any given quantity of a commodity is the marginal opportunity cost of producing the last unit. The first few units are relatively inexpensive to produce, because the inputs they use have low marginal opportunity costs. However, these costs rise as resources must be taken from increasingly valuable alternatives. Because of this, supply curves slope upward to the right, as shown below.

Figure 2-3



Supply curves

Solar energy is no exception to this price-quantity relationship, although many solar advocates have argued otherwise. They contend that the first units have high costs, because producing even one unit requires inputs such as factory space and tools. Thereafter, the added inputs are comparatively small and may be bought cheaply in large quantities. This implies that firms should be willing to mass produce solar modules at a lower price, so the supply curve slopes downward to the right. But this line of reasoning focuses only on purchase prices and ignores the opportunity costs of inputs such as land and materials.

Although supply curves represent price-quantity relationships, they also reflect existing market conditions and technologies. If these background market conditions change, so do supply curves. The figure shows two examples of possible changes. The solid curve, labled S, indicates the initial price-quantity trade-offs for suppliers. The dashed curve, S', assumes that something has caused the opportunity costs of inputs to be higher at all levels of production. An increase in population may make land and materials more valuable, high levels of employment may make labor more expensive, or demand for material inputs from competing industries may have increased the opportunity cost of using these materials for solar energy systems. The initial supply curve, S, shifts to S', since the cost of supplying any level of output is now higher. Supply is said to have decreased.

The dashed curve, labeled S", shows how changes in technology might affect supply. If a new research breakthrough allows the same output to be produced with fewer resources or less expensive inputs, then the supply curve shifts from S down to S". Each unit has a lower opportunity cost, and more units can be made at the same price. Supply has increased.

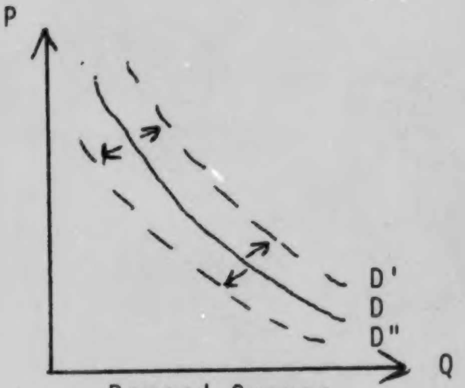
Demand Relationships

The forces that motivate producers to supply a good are important, but they are not the only factors at work in the marketplace. Production and pricing decisions also respond to the wants and needs of consumers. These wants and needs are the driving forces behind demand.

Like supply, demand is a price-quantity trade-off. When a commodity is relatively cheap, it is used in a wide variety of ways. As it becomes more expensive, people cut back on their less critical uses and substitute other products for it. If a commodity is expensive, only a small amount is purchased. On the other hand, lower prices induce users to buy more of the product. These purchasing decisions cause demand curves to slope downward to the right, as shown in figure 2-4.

Demand curves reflect consumer's purchasing decisions. They also represent existing preference patterns, incomes, and price conditions. As with supply curves, a change in any of these background circumstances also changes the demand curve. The shift of the demand curve from D to D' in the figure represents a situation in which demand has increased.

Figure 2-4



Demand Curves

This may be due to higher income levels, a growing, more affluent population, increasing prices of alternatives, or a change in tastes. At every price, more of the commodity is demanded. Alternatively, the shift of the demand curve from D to D" in the figure represents a situation in which demand has decreased. At every price, smaller quantities of the commodity are purchased.

Price Elasticity

Changes in any factor other than the price of the good--incomes, technology, the prices of alternatives and inputs--causes demand and supply curves to shift. If these background factors do not change, supply and demand curves provide a simple representation of the price and quantity decisions reached by buyers and suppliers.

An important piece of information contained within these curves is how responsive purchasing and supply decisions are to the price of the resource. For some commodities, a small change in price causes significant changes in buyer or producer behavior. In other cases, even large price changes do not affect production or consumption behavior very much. The size of a response to price changes depends on many factors: the availability and number of substitutes, the proportion of buyer income represented by the good, how time consuming a response is. These factors are incorporated into a measure of price responsiveness known as elasticity.

Numerically, elasticity is the percentage change in output (or purchases) divided by the percentage change in price causing the response. For example, a 10% price increase might cause suppliers to increase production by 5% and consumers to reduce purchases by 15%. In this case, supply elasticity would be 5% / 10% = 0.5, and demand elasticity would be -15% /10% = -1.5. Conceptually, elasticity indicates how readily market decisions can adjust to price changes. If output or consumption changes just equaled price changes, elasticity measures would have a value of 1.0 for supply and -1.0 for demand. This indicates that price changes have no impact on supplier revenues or buyer expenditures for the good. If the adjustment process is slow, or if few alternatives exist, responses to price changes are small, elasticity estimates are less than 1 in absolute value, and response is said to be inelastic. When response is elastic, price changes create even larger percentage responses in buyers and suppliers, and elasticity values are greater than one in absolute value. Returning to the first example, the supply response is inelastic, while demand response is elastic. Consumer response to price changes is greater than the response by suppliers.

Elasticity sometimes refers to an entire demand or supply curves. For example, the figure below illustrates four possible demand curves.

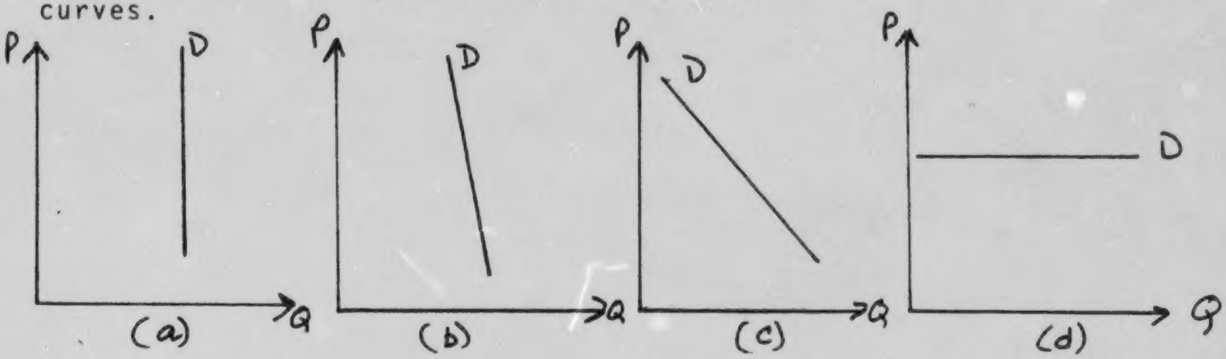


Figure 2-5 Variations in demand elasticity

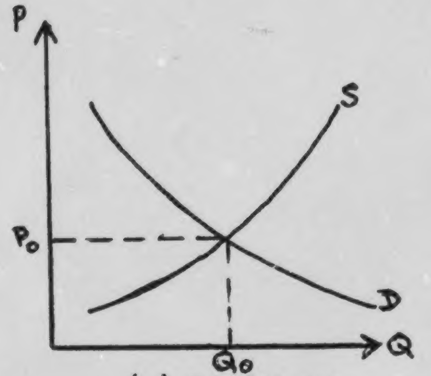
Figure (a) represents a completely inelastic demand; regardless of the price of the commodity, a given quantity will be purchased. The demand curve of figure (b) is elastic relative to (a), but inelastic when compared with the other diagrams. Changes in price cause consumers to alter the quantity or the commodity they purchase, but not by much. On the other hand, the demand curve of figure (c) is relatively elastic; small changes in price induce consumers to dramatically alter the quantity of the commodity they purchase. Finally, the demand curve of figure (d) is perfectly elastic; consumers can purchase whatever quantity they want at a given price.

It should be noted that perfectly inelastic and perfectly elastic demand curves are pedagogical tools rather than examples of actual conditions. However, some have attempted to argue that food and energy resources have totally inelastic demand curves. They reason that, because people need a certain amount of food and energy, they are at the mercy of suppliers and must pay whatever price suppliers ask. However, nobody goes to the store and buys a pound of food. Rather, they buy a pound of hamburger, a quart of milk, a dozen eggs, and so on. Suppliers of any one food type cannot raise prices indefinitely, since buyers would cut back their use of the expensive food and switch to alternatives. This ability to use alternatives is reflected in the elasticity of a demand curve. Commodities with many close substitutes will have relatively elastic demands.

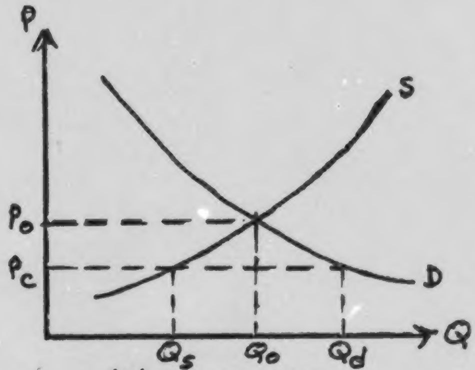
Supply and Demand

Each supply or demand curve contains an infinite number of possible price-quantity relationships. If analyzed in isolation, no demand or supply curve allows any conclusions to be drawn about the "suitable" price and production or consumption levels. The strength of these diagrams lie in their interaction, for it is the interaction of supply and demand forces that determines the value of each commodity in the marketplace.

As simple as demand and supply curves appear to be, they are powerful tools of analysis. The interaction of these curves, as shown in figure (a) below, determines the price, P_0, which users would willingly pay and suppliers would willingly accept for Q_0 units of output.



(a) Equilibrium



(b) Price ceilings

This price is the market value of Q_0, since it represents the interaction of production and consumption decisions. The price and quantity determined by this point of intersection is an equilibrium. It represents a price that both user and producer find satisfactory and a quantity of output at which firms are willing to supply exactly what consumers are willing to purchase.

As long as supply and demand conditions do not change, there are strong pressures to remain at an equilibrium. If regulatory constraints on prices or quantities attempt to set a different level, they do not invalidate these pressures. Quotas and price constraints merely transfer these market pressures to other areas.

Figure (b) above illustrates how these pressures appear elsewhere when special price legislation exists. Suppose a price ceiling were set at P_c; this is usually done when prices are felt to be too high. An example of such ceilings are the regulations on the prices of oil and natural gas produced in the United States. At price P_c, suppliers are only willing to provide Q_s units of the good. The price they receive just compensates them for their time and effort and covers the opportunity costs of providing the last unit they produced. However, consumers would like to buy Q_d units at price P_c. More units are demanded at the ceiling price than are supplied, and there is a shortage of $(Q_d - Q_s)$

units. If there were no price controls, consumers would tend to bid up the price of the good to ensure that they get some. Higher prices would induce suppliers to produce more and motivate users to reduce their purchases and switch to substitutes. This process would continue until price reached the equilibrium level P_0, at which suppliers have increased production by an amount $(Q_0 - Q_S)$. There is no longer a shortage, since buyers would like to obtain Q_0 units, which is exactly the quantity produced.

But if price controls keep the price at P_C, the shortage will persist. Suppliers will have no incentive to provide more goods at prices lower than those available elsewhere. On the other hand, buyers have no reason to conserve or use alternatives when the commodity is so inexpensive. The shortage caused by price ceilings manifests itself in several forms. Prices rise in nonobvious ways. For example, people must wait in line for gasoline, or no new natural gas hookups take place and existing service may be allowed to deteriorate. These longer waits and poorer-quality service increase the cost of delivered energy. Existing supplies are rationed out to people who have good connections or want some badly enough to wait in line or pay a premium.

This analysis has important implications for solar energy. If widespread usage of solar power is considered to be desirable, legislation to keep module prices low (to promote purchases) or high (to promote production) will not ensure widespread usage. Price legislation is more likely to create a surplus or shortage than the diffusion of a solar technology.

Higher prices are not bad in and of themselves. The price mechanism rations scarce resources, promotes conservation, and motivates a search for substitutes. However, when the mechansim is constrained by price ceilings or quotas, a large number of side effects appear. Legislation can regulate what is put on a price tag, but it cannot invalidate market forces.

Market Value

As long as the market continues to operate without interference, supply and demand interactions will determine market equilibrium. However, market equilibrium can be altered by changes in production and consumption decisions. There are four basic ways in which equilibrium can be altered. They all require changes in the underlying market conditions, and hence they involve shifts in the supply and demand curves.

Figure 1, on next page, illustrates the four kinds of changes that may take place.

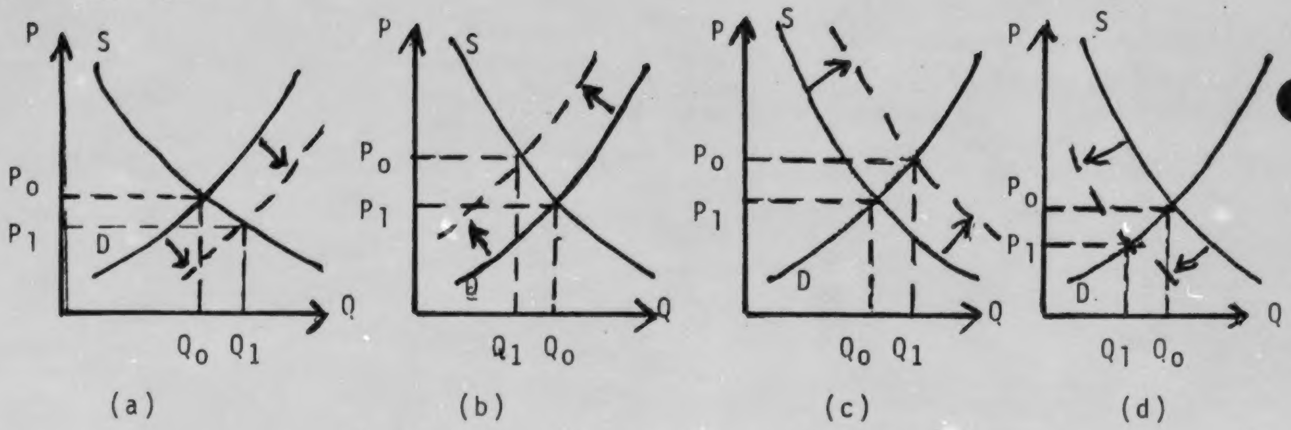


Figure 1: Changing equilibria

In case 1(a), supply has increased--this may happen for a number of reasons: a technological innovation might occur so that fewer inputs are needed to produce each level of output, or inputs might be cheaper or more plentiful. Whatever the reason, producers can now supply the same amount of the commodity at a lower price or more at the same price. After the supply curve shifts, the new equilibrium price moves from P_0 to P_1. As the price falls, users begin to purchase more and consumption increases from Q_0 to Q_1. This shift is probably the most desirable change that can take place for solar energy technologies. More of the commodity is used, and users can obtain it at a lower unit price.

However, case 1(b) seems to be more common. As inputs become more costly or as new rules and regulations add to the production procedure, opportunity costs increase and supply decreases. Fewer units of the commodity are used, and each unit costs more to produce and to buy. Demand can also shift--case 1(c) illustrates what happens when demand increases. This happens when tastes change, when buyers become wealthier, or when the prices of substitutes rise. More of the commodity is used, but increased demand has also caused the price to increase. Prices are higher, but tastes have changed or incomes have risen enough so that consumers are willing to pay those higher prices.

Finally, case 1(d) shows what might happen if safety problems or health hazards suffered or if newer, cheaper alternatives appeared on the market. As buyers switch to alternatives, demand decreases. At the new equilibrium, consumers pay less for each unit of output than they did previously, but because of the hazards involved or the availability of substitutes, consumers are not willing to purchase as much as before.

Changes in market conditions also depend upon the elasticity of demand and supply; figure 2 on next page shows why.

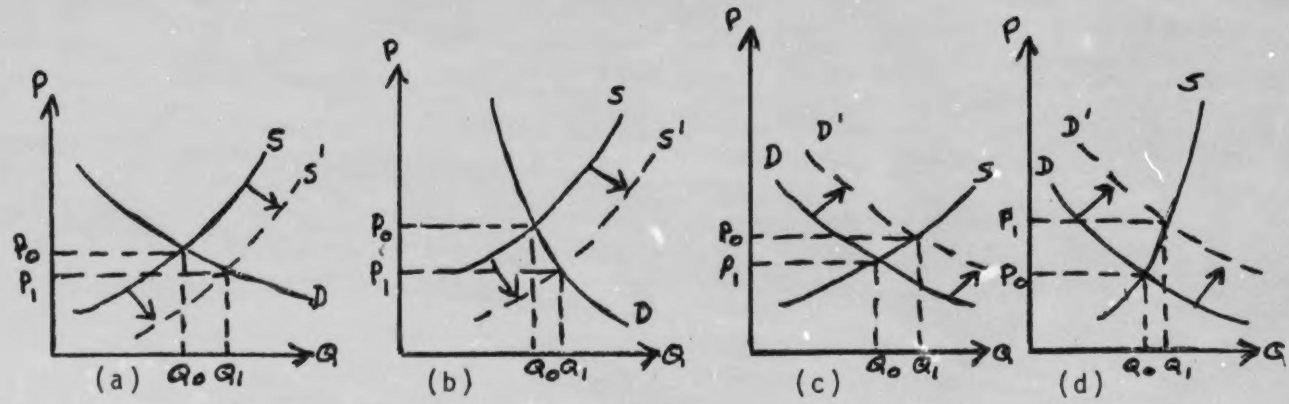


Figure 2: Effects of elasticity

If the demand curve is relatively elastic, a shift in supply will result in comparatively large usage increases and relatively small price decreases. Demand in case 2(a) is more elastic than in case 2(b). Thus, an equal increase in supply in each instance will create a larger quantity increase in 2(a) than in 2(b). Similarly, cases 2(c) and 2(d) show how supply elasticity affects results. For an equal increase in demand, an elastic supply curve provides a larger quantity response than would be otained with a relatively inelastic supply.

If additional usage of solar energy is considered desirable, an increase in supply can simultaneously increase output and lower per-unit price paid. Shifts in demand cannot accomplish both. An increase in demand will cause the amount purchased to rise, but a higher price is paid for each unit. Price decreases will result from decreases in demand, but the number of units sold will also decrease.

An example of these conflicting forces appears in the different ways the federal government has attempted to accelerate photovoltaic usage. There are two ways in which the government could accomplish its goal of increased usage. First, it could put public funds into R & D programs in an attempt to lower costs through new technical breakthroughs and design innovations, thus increasing supply. As the price falls, consumers increase their purchases, as was shown in figure 1(a).

Alternatively, the government could effect cost reductions through mass production by directly purchasing photovoltaic units. A federal purchasing program, such as FPUP (Federal Photovoltaics Utilization Program), also attempts to shift supply. But it has the additional side effect that government purchases directly increaseed demand. This increased demand will further stimulate photovoltaic output, but it will also bid up the price of solar modules. Figure 3(a) illustrates the case in which the final price, P_1, is still below the initial one, P_0. However, figure 3(b) illustrates a situation in which the final price is higher than the original price. If the increase in demand produces only small changes in the supply technology, overall price will rise.

Many factors must be considered when choosing between R & D programs and federal purchases. The benefits from R & D are more uncertain, since ttchnological breakthroughs and cost reductions cannot be counted upon. If no innovations are developed, supply may not change at all. Federal purchases guarantee that more units are used than would have been otherwise, but they also create upward price pressures.

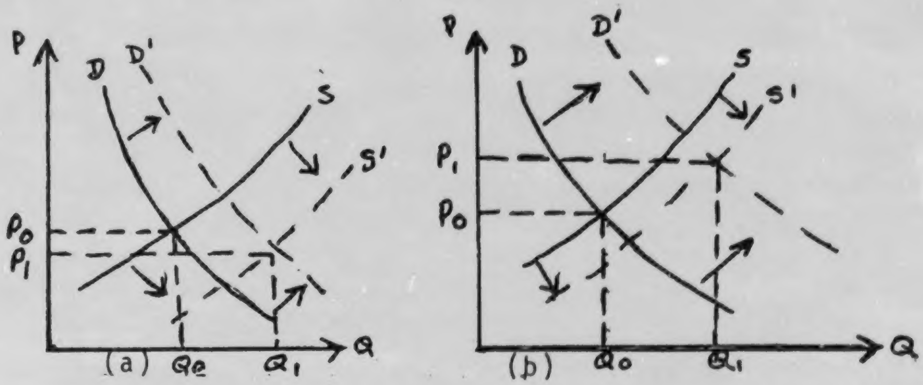


Figure 3: Changing market value under FPUP

CONVERTING COSTS AND SAVINGS TO EQUIVALENT BASE

All solar systems require a large initial investment to realize a modest annual rate of return in terms of fuel savings. To be economical, the solar system must perform for many years, returning its initial cost plus interest over a long lifetime. It is of no consequence whether the money invested is borrowed or not. No matter who is the owner, capital should return proper interest, for there are always other profitable investments to be made.

If an aggressive 12% interest is required and no allowance taken for advancing fuel prices, probably no existing system is economical. On the other hand, if a 6% interest is satisfactory and a 10% annual increase in fuel costs is assumed, almost any system will be very profitable.

A necessary step in any comprehensive economic evaluation method is the adjustment of the various cost items to an equivalent time basis. This adjustment is necessary because an investment in solar energy results in expenditures and savings that occur both in the present and in the future, and there is a difference between the value of a dollar today and its value at some future time. This time dependency of value reflects not only inflation, which may reduce the purchasing power of a currency, but also reflects the real earning potential of money. The methods of economic evaluation to be discussed later, include appropriate adjustments for the timing of cash flows in the formulation of the method. However, some discussion in more detail of the whys and hows of converting costs and savings to a common time and common dollar measure, are prerequisite.

Discounting Cash Flows

The starting point for all economic analyses is the time value of money. A procedure for adjusting for the time value of money is a technique often called "discounting". Discounting refers to the use of interest formulas to convert cash flows occurring at different times to equivalent amounts at a common point in time.

If a sum of money is in hand and has a present value of P, it will be worth at a future time a value F given by:

$$F = P(1 + ni) \tag{1}$$

where i is the fractional interest rate,
n is the number of years into the future at which F is to be evaluated.

If the interest is compounded annually (and this is routinely the basis for economic evaluations), then repeated application of equation (1) at one-year intervals results in the annual compound interest relationship:

$$F = P(1 + i)^n \tag{2}$$

The equivalence expressed in equation (2) between the value of money now and in the future is fundamental. Modern investment analysis refer all future returns of money to the present time by use of a rearrangements of equation (2):

$$P = \frac{F}{(1 + i)^n} \qquad (3)$$

where i has been renamed the discount rate. Thus, future money is not as valuable as money at the present, and must be "discounted" by the factor $1/(1 + i)_n$.

Discount Formulas

To discount cash flows to equivalent values at a common time, an appropriate interest formula (or "discount formula") is applied to each cash amount. Alternatively, to simplify the calculation, interest factors (or "discount factors") precalculated from the discount formulas can be multiplied by the cash amounts. The discount formulas most frequently used in investment analysis are the following:

1. The uniform capital recovery formula, CRF, which when applied to a present amount converts it to an equivalent series of level annual payments;
2. The single compound amount formula, SCA, which when applied to a present amount converts it to an equivalent value at a future time;
3. The single-present-value formula, SPV, which when applied to a future amount converts it to an equivalent present value;
4. The uniform compound amount formula, UCA, which when applied to a recurring annual amount converts it to an equivalent lump-sum amount at a future time;
5. The uniform sinking fund formula, USF, which when applied to a given future total value indicates the annual amount required to achieve the future total value;
6. The uniform-present-value formula, UPV, used to find the equivalent present value of a series of level annual amounts.

Table 1 gives the nomenclature and algebraic expression for each of these discount formulas. Tables 2 throuth 7, located "in the appendix, give the counterpart discount factor for selected time periods and discount rates.

Table 1: Summary of Interest Factors for Cash Flows with End of Period Compounding*

Discount Formula	Interest Factor	Quantity Known	Quantity to be Found	Discrete Compounding of a Discrete Flow Expression	Continuous Compounding of a Discrete Flow Expression
CRF	(A/P,i,N)	P	A	$\frac{i}{1-(1+i)^{-n}}$	$\frac{e^{r} - 1}{1-e^{-rN}}$
SCA	(F/P,i,N)	P	F	$(1+i)^{N}$	e^{rN}
SPV	(P/F,i,N)	F	P	$(1+i)^{-N}$	e^{-rN}
UCA	(F/A,i,N)	A	F	$\frac{(1+i)^{N}-1}{i}$	$\frac{e^{rN}-1}{e^{r}-1}$
USF	(A/F,i,N)	F	A	$\frac{i}{(1+i)^{N}-1}$	$\frac{e^{r}-1}{e^{rN}-1}$
UPV	(P/A,i,N)	A	P	$\frac{1-(1+i)^{-N}}{i}$	$\frac{1=e^{-rN}}{e^{r}-1}$
GF	(A/G,i,N)	G	A	$\left[1/i-N/i(A/F,i,N)\right]$	**

* CRF = Capital Recovery Factor,
SPV = Single present value,
USF = Uniform Sinking Fund
GF = Gradient Factor,
F a future amount,
G is the uniform increase in an amount
r is the nominal rate

SCA = Single Compound Amount,
UCA = Uniform Compound Amount,
UPV = Uniform Present Value,
P is a discrete present amount,
A a uniform end of period payment
i is the effectaive interest rate,
N is the number of payment periods

**Substitute $i = e^{r}-1$ into the previous column expression for the uniform gradient factor.

Discount Rates

To apply the discount formulas or factors, it is necessary to select a discount rate. The discount rate should reflect the investing person's or firm's time preference for money (or, more accurately, the resources money can buy). Apart from inflation, time preference reflects the fact that:

1. Money in hand can be invested to earn a return;
2. Money borrowed requires interest to be paid.

Of these two factors, the former, often called "the opportunity cost", is generally predominant in establishing a discount rate. If there is a limit on the total funds available for investment from all sources including borrowing, the most important element in determining the discount rate is the rate of return which would be forgone on the next-best investment if a given investment is undertaken. This rate can be higher than the borrowing rate, and needs to be accounted for in an investment analysis even if funds are not borrowed. The discount rate, then, stipulates a minimum rate of return which must be recovered on an investment over and above other investment costs.

A discount rate may be either "nominal" or "real". A nominal discount rate reflects both the effects of inflation and the real earning power of money invested over time. A nominal rate is appropriate to use only in combination with cash flows which also include inflation. Market rates of interest, such as the mortgage rate on building loans, are nominal rates.

A real discount rate reflects only the real earning power of money and not inflation. It is appropriate for evaluating investments if inflation is removed from the cash flows prior to discounting, i.e., if they are already stated in constant dollars.

The relationship between a nominal rate of interest and a real rate of interest may be described as follows:

$$i = d + I = dI,$$

where: i is a nominal rate of interest
d is a real rate of interest
I is the expected rate of inflation

Note that the nominal rate is not equal simply to the real rate plus the rate of inflation. The rate of inflation is reflected in the nominal rate in two terms.

I, the rate of inflation
dI, the product of the real rate and the rate of inflation

There is no single discount rate--whether calculations are in real or nominal terms--that is appropriate for discounting all cash flows. A wide range of rates is used in practice, and there is a subjective element in the choice of rates. The important thing is that the discount rate reflect the investor's time preference.

The choice of rates can significantly affect the outcome of an evaluation. The higher the rate, the lower the value of future cash flows. The lower the rate, the smaller the effect of discounting on future cash flows.

Timing of Cash Flows

In the case of most investments, expenditures and receipts or savings occur throughout the year. Some occur annually, others semiannually, quarterly, monthly, weekly, daily, or even nearly continuously as in the case of cash receipts from sales. Seldom, however, are cash flows modeled exactly as they occur within a year. To simplify the analysis, they are commonly assumed to occur in lump sums either at the beginning, middle, or end of each year, or continuously throughout the year.

The discount factors contained in Tables 2 through 7 in the appendix can be used to discount cash flows on either a beginning-of-period or an end-of-period basis simply by designating the initital period index as 0 (beginning) or 1 (end). By averaging the discount factors for two consecutive periods, discount rates reflective of middle-of-the-period payments can be developed. For example, the single-present-value factor for midway between the first and second years is 0.9545 for a discount rate of 10 percent. This is derived by averaging 1.000 the discount factor for a cash flow occurring at the beginning of the first year, and 0.9091, the discount factor for the cash flow occurring at the end of the first year.

If a continuous flow model is desired, conversion factors discussed above under "discount formulas" can be used.

Treatment of Inflation

Removal of inflation from cash flows is essential for a valid economic evaluation of an investment. Otherwise, the evaluation is made in variable-value dollwrs, and makes no economic sense. Removing inflation means measuring cash amounts in terms of the value of the dollar in a base year, usually the time at which the investment decision is made. There are several alternative ways of removing inflation from cash flows. Briefly, they are:

1. Exclude inflation from the analysis at the outset by assuming that all cash flows are fully and evenly responsive to inflation and, therefore, remain constant in terms of base-year dollars;

2. Include expected price changes in cash-flow estimates and then remove inflation prior to discounting by the use of a constant dollar price deflator based on past inflation rates or predicted ones;

3. Include expected price changes in cash-flow estimates (i.e., use current dollars) and discount the cash flows with a discount rate that includes the expected rate of inflation, in addition to the investor's real potential earning rates.

The choice of approaches depends in part on the expected pattern of price change. The simplest approach is the first, that is, to omit inflation from analysis by assuming that inflationary effects cancel out, leaving the outcome unchanged. For example, other things being equal, if the cost of labor to perform a given maintenance service for a solar energy system is expected to change at about the same rate as prices in general, the cost of that service in the future in constant dollars can be assumed to be the same as it is today. If there is not a compelling reason to assume that the prices of particular goods and services will inflate differently from prices in general, this convention of assuming base-year prices to hold for future constant dollar prices is a widely accepted practice of analysis.

In the absence of income tax effects, inflation generally will not affect the outcome of an investment whose cash flows are fully and evenly responsive to inflation. However, when tax effects are considered, inflation may significantly affect the investor's profitability. For example, under existing tax practices, the tax benefit from depreciation is received in future dollars, but is measured in the dollars of the initial investment. This results in a decline in the value of the tax benefit, other things being equal.

Future prices of goods and services relavant to the investment may not, however, respond fully and evenly to inflation in such a way that they remain level in constant dollars. Alternatively, the future value of an item may rise at a rate faster than general price inflation. For example, mortgage loans are fixed over time and fall in value when measured in constant dollars. Alternatively, the future value of an item may rise at a rate faster than general price inflation. For example, forces of demand and supply are widely expected to increase the price of non-renewable energy sources faster than most other prices.

If future prices are fixed at current levels or for some other reason are not expected to respond fully to price inflation, it is important that these future values be converted to constant dollars. This can be done by following the second approach above and applying a price deflator to each future annual payment prior to discounting, or by following the third approach and discounting the future annual payments with a discount rate that includes inflation.

If future prices are expected to rise faster than general price inflation, the adjustment to constant dollars is usually made in one of two ways:

1. A variation of the first approach described above;

2. The third approach described above.

In the first approach, inflation *per se* is excluded from the estimates of future cash flows. However, the *differential* price increase, that is, the expected price change over and above the general rate of inflation, is included in the future cash flows. In accordance with this procedure, a real discount rate (exclusive of inflation) is used to further adjust for time preference.

Escalation of Nonrenewable Energy Prices

The fact that energy prices are widely expected to increase (escalate) faster than the rate of increase in the general price level is a major force behind the growing interest in solar energy. To reflect this expectation, energy prices are usually escalated in evaluating the economic performance of solar energy. As in the case of other cash flows, however, it is important to eliminate the effects of changes in the purchasing power of the dollar and to express future energy costs in constant dollares.

The economic performance of the solar energy system tends to be quite sensitive to the choice of a fuel price escalation rate. Selecting a high rate raises savings relative to costs and can easily change the evaluation of a system from economically unprofitable to economically profitable. For example, Table 28.8 shows the effect of several different price escalation rates on the present value of a yearly savings of 100 million Btu of electricity priced initially at $0.035/per kWh, and discounted at a rate of 10 percent.

TABLE 28.8 Impact of Alternative Eenrgy Price Escalation Rates on Present-Value Energy Savings in a Hypothetical Case

Energy price escalation rate percent	Present value of 10×10^7 Btu energy savings over 25 years,* dollars
0	9,308
5	14,858
10	25,635
15	48,060

*Discounted at a rate of 10% and priced initially at $0.035/kWh.
NOTE: This example examines only savings, not costs, of a purely hypothetical solar energy system.

Over a 25 year period, the present-value savings of 100 million Btu of electricity ranges from a low of $9308 with no price escalation and a discount rate of 10 percent to a high of $48,060 with a price escalation rate of 15 percent and a discount rate of 10 percent. When the fuel price escalation rate is exactly equal to the discount rate, they offset one another, and the net present value is equal simply to the yearly savings multiplied by the number of years, or $25,635.

Without escalation of future cash flows, discounting tends to reduce them eventually to the point at which they are so small in present-value terms as to be of little consequence to the outcome of the evaluation. For example, with a 10 percent discount rate, a dollar to be received in five years is worth \$0.62 today, in 10 years, \$0.38, and in 15 years, only \$0.24. However, including a relatively high price escalation rate can cause cash flows expected in the distant future to weigh significantly in the outcome.

Because of the considerable uncertainty about energy prices in the distant future, caution is advisable in specifying a long-term rate of price escalation. One approach that may be taken to reduce the impact of ever-compounding fuel prices in distant years is to limit the period over which the investment is to be evaluated. Another approach is to use a short-term escalation rate for the period in which rising prices seem assured, and a somewhat lower long-term rate for the period for which there is greater uncertainty.

Economic Life of Principal Assets and Period of Analysis

A life-cycle analysis requires the designation of economic life expectancies for an investment's principal assets. The economic life of an asset is that period during which the asset is expected to be retained in use for its intended purpose at the minimum cost for achieving that purpose. The useful life is that during which the asset is expected to serve a useful purpose.

The economic or useful life expectancy of solar energy systems is difficult to estimate with a high level of confidence. The relatively short period in use of most solar energy systems limits the possibilities for basing life expectancies on actual data samples, although some insight may be gained by examing historical durability data for individual components of solar energy systems that have been used in other, related capacities. For the most part, analysts must rely upon durability information from manufacturers, trade and professional journals, and research reports.

The comprehensive methods of evaluation require the analyst to specify the length of time over which an investment is to be evaluated. In establishing the time-frame of analysis, the following requirements should be met:

1. In comparing solar energy systems with conventional energy systems, all alternatives should be evaluated on the basis of the same time frame;
2. In evaluating an investment for a period shorter or longer than the expected physical lives of the principal components, any significant residual salvage values or replacement costs should be taken into account;
3. The period over which an energy system is to be analyzed should not exceed the life expectancy of the facility in which it is used, e.g., building life normally imposes a constraint on the life of the energy system.

In using a present-value measure to compare alternative energy systems, it is important that the alternatives be evaluated for an equal time period. Often a time cycle is chosen that will permit enough renewals of each alternative that the cost of their economic lives coincides with no remaining salvage value. For example, in comparing a system with a 20-year life with one having a 30-year life, the present value of each could be examined over 60 years. This would require two renewals of the 20-year system and one renewal of the 30-year system.

Alternatively, if the length of time over which the energy system is needed is limited, e.g., 10 years, both systems would be evaluated for 10 years, with any renewal costs on salvage values remaining for either at the end of the 10 years taken into account.

If it is reasonable to assume that the system will be needed indefinitely, the annual cost measure may be calculated on the basis of the economic life of each system. This eliminates the necessity of evaluating both systems for the same length of time and including renewal costs and salvage values. With indefinite need for a system, for example, the annual cost of the 20-year-life system could be calculated on the basis of 20 years and compared with the annual cost of the 30-year system calculated for 30 years. Evaluating alternatives on the basis of their respective lives without the need to include renewals and salvage can in some cases considerably simplify the calculations. The annual-cost measure is sometimes preferred over the present-value measure for this reason.

Examples of Discounting

The different patterns of cash flows generated by investments in solar energy systems require the use of the various discounting formulas. To select the appropriate discounting formula, it is necessary to decide whether cash flows are to be expressed in terms of (1) a present value or (2) an annual value, i.e., a series of level values over time. The time basis is largely a matter of preference; either will serve as well as the other for the purpose of an economic comparison, as long as a consistent approach is followed for the cash flows of a given investment.

Table 28.9 illustrates the conversion of various costs and savings, typical of those that might result from an investment in solar energy, to present-value and annual-value equivalents. The examples are based on the specific assumptions given in the table.

The first column describes the type of cash flow. The second column uses a "cash-flow diagram" to show the timing of that particular cash flow. The horizontal line of the cash-flow diagram is a time scale, where P indicates the present; the progression of time moves from left to right, and the numbers between the points represent years. The downward-pointing arrows represent expenditures (cash outflows), and upward-pointing arrows represent receipts or savings (cash inflows).

The first row shows the discounting of planning and design costs assumed to have been incurred at the beginning of the past year. To convert this past cost to a present value, the single compound amount factor for 1 year and the assumed discount rate of 8 percent is used. To convert the past amount to an annual value, it is first converted to a present value and then to an annual value by applying the uniform capital recovery factor. Thus, in cols. 3 and 4 of Table 28.9, it may be seen that paying $500 a year ago is equivalent to paying $540 now (apart from inflation), or to paying $63 each year over the next 15 years, under the stated conditions.

The second and third rows of Table 28.9 show the discounting of current expenditures associated with acquiring and installing the system on the building. These values are already stated as present values and need only be converted to annual values by application of the uniform capital recovery factor. (Tax and financing effects are treated later.)

The fourth row of Table 28.9 shows the discounting of a series of yearly maintenance costs that are level in constant dollars. The uniform-present-value factor is used to convert the series of yearly expenditures of $60 to a present-value equivalent of $514. There is no need for any adjustment to derive the equivalent annual value because the cash flow is already expressed in annual terms.

The fifth row shows the discounting of repair and replacement costs. These costs consist of future payments that occur less often than every year. The single-present-value is used to convert the expected amounts of $100 in the fifth year and $100 in the tenth year to the total present-value equivalent of $114. The uniform capital recovery factor is used to convert the present value of $114 to an equivalent annual value of $13.

The sixth row shows the discounting of a single future receipt, the net salvage value of $3000 that the solar energy system is assumed to yield at the end of the period of use. Again, the single-present-value factor is used to convert the future value to a present-value equivalent of $946. The annual-value equivalent of $110 is found by applying the uniform sinking fund factor to see how much money would be necessary to invest annually in order to accumulate the specified amount by the designated time.

The seventh row of Table 28.9 shows the discounting of expected energy savings. The yearly increase in the amount of savings reflects the assumption that energy prices will rise substantially faster than prices in general. At the outset, yearly savings are estimated at $1000. To find the present value of the life-cycle savings, it is necessary both to escalate the yearly savings and to discount them. This is done by using the variation of the uniform-present-value formula. The present-value equivalent of yearly energy savings is $12,959, under the stated conditions. The annual-value equivalent is $1514, found by applying the uniform capital recovery factor to the present-value amount.

The discounted cash flows may now be used to evaluate the profitability of the investment by computing, for example, the total life-cycle cost of the investment, the net savings from the investment, or the savings-to-investment ratio. In this simplified example, the net present-value savings from the investment, found by subtracting the total present value of costs, less salvage value, from the total present value of fuel savings, is $3137 (i.e. $12,959 - [$540 + ($9000 - $946) + $600 + $514 + $114] = $3137). In annual-value terms, total costs amount to $1147 and total savings to $1514, resulting in a net annual savings of $367. Thus, under the stated conditions, saving $3137 in present-value terms over 15 years is equivalent to saving $367 each year for the 15 years.

LE 28.9 Examples of Discounting Cash Flows for a Solar Energy Investment[a]

Type of cash flow (1)	Cash flow diagram (2)	Present-value equivalent (3)	Annual-value equivalent (4)
Engineering design, and planning	P −1 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 $500	P = $500 (SCA, 8%, 1 year) = $500 (1.0800) = $540	A = $500 (SCA, 8%, 1 year) (UCR, 8%, 15 years) = $500 (1.0800) (0.11663) = $63
Purchase and installation	P 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 $9000	P = $9000 (1) = $9000	A = $9000 (UCR, 8% 15 years) = $9000 (0.11683) = $1051
Building modifications	P 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 $600	P = $600 (1) = $600	A = $600 (UCR, 8%, 15 years) = $600 (0.11683) = $70
Maintenance and operation	P 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 60 60 60 60 60 60 60 60 60 60 60 60 60 60 60	P = $60 (UPV, 8%, 15 years) = $60 (8.559) = $514	A = $60 (1) = $60
Repair and replacement	P 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 $100 $100	P = $100 (SPV, 8%, 5 years) + $100 (SPV, 8%, 10 years) = $100 (0.6806) + $100 (0.4632) = $68 + $46 = $114	A = [$100 (SPV, 8%, 5 years) + $100 (SPV, 8%, 10 years)] (UCR, 8 %, 15 years) = [$100 (0.6806) + $100 (0.46323)] (0.11683) = (68 + 46) (0.11583) = $13
Salvage of system end of 15 years	$3000 P 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	P = $3000 (SPV, 8%, 15 years) = $3000 (0.3152) = $946	A = $3000 (USF, 8%, 15 years) = $3000 (0.03683) = $110
Fuel savings	P $1060 1, $1124 2, 1191 3, 1263 4, 1338 5, 1419 6, 1504 7, 1594 8 1690 9, 1791 10, 1898 11, 2012 12, 2133 13, 2261 14, 2397 15	$P = \$1000 \sum_{t=1}^{15} \left(\frac{1+0.06}{1+0.08}\right)^t = \$1000\,(\text{UCR, 1.89\%, 15 years})$ $= \$1000\,(12.956) \qquad \left(1.89\% = \frac{0.08-0.06}{1.06} \times 100\%\right)$ = $12,959	$A = \$1000 \sum_{t=1}^{15} \left(\frac{1+0.06}{1+0.08}\right)^t (\text{UCR, 8\%, 15 years})$ = $12,959 (0.11683) = $1,514

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[a] Based on the assumptions that all cash flows are in constant dollars, a real discount rate of 8% is used, the system has already been designed and is ready for purchase and installation, the solar energy system has an expected life of 25 years, conventional energy prices are expected to escalate at a real rate of 6%, the investor has a time horizon of 15 years, and the system has a salvage value of 00

NOTE: SCA = single compound amount factor. (SCA, 8%, 1 year) denotes the factor for 1 year at 8% interest.
UPV = uniform-present-value factor
SPV = single-present-value factor
UCR = uniform capital recovery factor
USF = uniform sinking fund factor

CASH FLOW COMPONENTS

A comprehensive evaluation of solar and conventional heating and/or cooling systems requires the assessment of the following kinds of costs over the life cycle:

1. System acquisition costs, including design, engineering, and "search costs" if they are important, purchase prices, delivery costs, and installation costs;

2. Costs or savings due to changes in the building envelope or in other building components that must be modified to accommodate the solar energy system;

3. System repair and replacement costs;

4. Maintenance costs;

5. Energy costs;

6. Salvage values, net of removal and disposal costs;

7. Insurance;

8. Taxes;

9. Governmental incentives.

These various kinds of costs are required for all parts of the systems being compared. For a solar energy system for a building, the principal parts may comprise the following:
1. solar collector;
2. thermal storage;
3. domestic hot-water system;
4. air-conditioning components;
5. auxiliary energy system;
6. heating and cooling distribution systems;
7. the system control;
8. any motors, pumps, fans, flowers, wiring, and tubing included in these parts.

If the energy systems that are to be compared have parts which are identical in costs, the costs of these parts may be omitted for the purpose of comparing the economics of the systems. For example, often it is assumed that the acquisition costs, as well as the reliability, durability, maintenance, and repair costs, of the conventional auxiliary system are the same as those of the conventional system used alone. This assumption reduces the number of cost elements to consider and simplifies the analysis.

Where the costs of alternative systems differ, the costs of each may be assessed in full and then compared; or alternatively, the costs attributable to the solar energy system can be calculated by subtracting the cost of the conventional system from the cost of the combined solar/auxiliary system for each item of cost.

System costs (other than insurance, taxes, and incentives) may be further divided into:
1. engineering,
2. materials,
3. labor,
4. marketing costs.

This division of costs may be useful for the purpose of current cost control and for predicting future system costs. For example, it has been predicted that system design, engineering, and research costs will tend to decrease as the number of solar installations increases and the knowledge of system size requirements for alternative locations and standardized designs expands. As another example, there may be cost tradeoffs between materials and labor that could reduce further total system costs. Factory preassembly of solar collectors in modular form, for instance, tends to increase materials costs (as compared with assembly at the job site), but may lower labor costs of assembly through techniques of mass production in the factory.

Some kinds of costs may be difficult to lower. Labor costs for collector installation, for example,may be more difficult to reduce than labor costs for system assembly. Similarly, materials costs may be difficult to reduce apart from a switch to innovative designs that use fewer and/or less expensive materials.

The realtive proportions of the various kinds of costs may differ considerably, depending on the type of application. For example, the relative proportions of materials and labor costs may differ for new construction and for retrofit installations. Installation of a collector as an integral part of the building during construction tends to displace a portion of roofing labor costs, whereas retrofit of a collector to an existing building may require additional materials costs for structural support of the roof.

Fixed Costs and Variable Costs

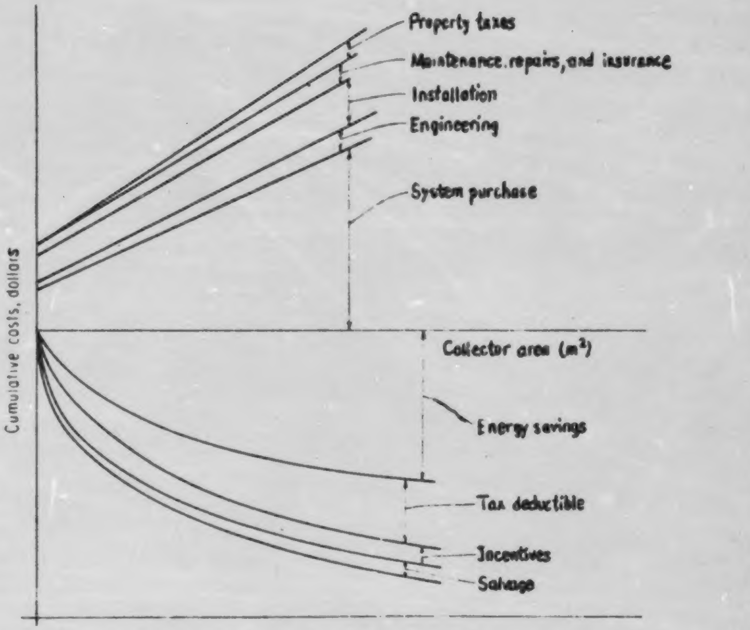
Another cost concept--one that is particularly useful in determining the optimal system size--is the division of costs into fixed and variable components. Fixed, or constant, costs are those that do not change as the size of the solar energy system is increased. (Few costs are truly unchanging as the capacity of the system is changed; but some costs do tend to be somewhat fixed over a restricted range of system sizes.) For example, the need for a reliable energy source may mean that the capacity of the conventional backup system will be held constant over a wide range of solar energy system sizes. Additionally, most of the other components of a solar energy system will have some portion of their costs fixed for alternative total system sizes. For example, a solar energy system of any size will require a minimum of controls, pumps, tanks, heat exchangers, valves, piping, fittings, etc. that will tend to remain about constant over some range as the size of the collector area is expanded. The cost of the collector panels, storage, and heat exchangers, usually comprises the major item of variable costs. Collector installation generally has both a fixed and a variable cost

The figure to the right illustrates the fixed and variable elements typical of the major items of costs for a solar energy system.

The vertical axis measures costs, and the horizontal axis measures collector area.

The upper quadrant of the figure shows items that raise the cost of solar; the lower quadrant shows items that lower the cost.

Cost curves that originate at the origin or at the point of origin of the cost curve just below it, have no fixed element. If they maintain a constant distance from the curve just below, they have no variable element. If they diverge as collector area increases, they encompass a variable element.



Fixed and variable cost components. (Fixed costs are the differences in the intercepts of the upper arrows

To estimate the costs of alternative systems, it is useful to identify the fixed and variable portions of system costs, and to calculate the variable portion of costs as a function of collector area. For example, the cost of a component such as storage may be estimated as follows: $S = F + sAP$

where: S is total storage costs,
F is fixed costs for tanks, valves, etc.,
s is units of storage medium per unit of collector area,
A is collector area,
P is price per unit of storage medium.

By dividing all systems costs into fixed and variable components, the cost-estimateing equation for the system can be simplified. Because fixed costs are incurred regardless of the size of the system, they influence the optimal size. This is because it is the changes in costs and savings as system size is expanded that determine the optimal system size.

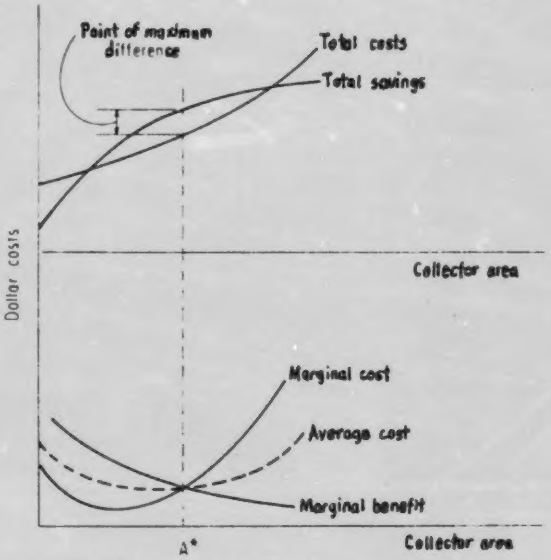
Total, Average, and Marginal Costs

The changes in costs and savings that result from an increment in the size of a system are known in economics as the "marginal cost" and the "marginal savings", respectively.

The marginal costs and savings are the derivatives of the total costs and savings, and when equated, result in the maximum level of net savings, measured as the difference between total cost and total savings.

The figure to the right illustrates the typical relationship between total costs, total savings, marginal costs, and average costs.

These concepts apply to costs and savings stated in life-cycle cost terms.



The relationship of total, marginal, and average costs of a solar energy system

Acquisition Costs

Costs incurred initially (first costs) are already in present-value terms and require no further adjustment if a present-value model is used. If an annual-value is used, it is necessary only to multiply the total of first costs by the uniform capital recovery factor UCR.

Acquisition costs may be treated entirely as a first cost if it is assumed that the system is purchased outright, or if no difference is assumed in the discount and the mortgage loan rates. Otherwise, only the down-payment portion of acquisition costs is treated as a first cost, and the present value of the remaining costs is found by first applying the RCR based on the mortgage loan rate of interest, and then applying to the level, periodic mortgage payment the uniform present value factor UPV based on the discount rate. Note that the mortgage payment is fixed and declines in constant dollars during inflationary periods.

There is considerable uncertainty about the installed costs of solar heating systems, and there is insufficient information available to substantiate published reports. System costs based on research projects and demonstration projects funded by the Federal Government are misleading, because the total costs of such projects may include considerable design and engineering. In some instances, instrumentation for monitoring the performance of experimental systems and the cost of developing alternative components are included. The costs reported in popular magazines and newspaper accounts are likewise misleading, because they are often based on systems which have been designed and assembled by the owner on a do-it-yourself basis. Installation labor, normally a major cost item, is seldom included.

Guidelines are provided in the following discussions to estimate the total installed cost of a solar system including equipment and installation labor. Of these two items, equipment costs are the larger and easier to estimate, largely by consulting manufacturer's literature and price lists. Estimating labor costs is more difficult because it depends upon the type of installation, location of the house, experience of the installer, and other factors. Ranges in equipment price and estimates of man-hours for installation of systems in new buildings (in 1978) are listed below to provide cost-estimating guidelines. There may be specific items of equipment which have lower costs than those listed, and some which are more expensive, so that prices may not be representative of any single project.

TYPICAL EQUIPMENT AND MATERIAL PRICES (IN 1978) FOR LIQUID-HEATING SYSTEM

ITEM	UNIT	PRICE RANGE (IN DOLLARS)		
		LOW	MEDIUM	HIGH
Flat-plate collectors and mounting hardware	ft^2	10	15	24
Storage tank	750-1200 gal capacity	1000	1500	2500
Pumps and motor	10-20 gpm	80	180	350
Heat exchanger	Each	200	300	400
Controls and sensors	Each	500	750	1500
Piping (3/4 inch copper)	ft	0.45	0.60	0.80-.85
Valves	Each	20	30	45
Miscellaneous fittings	--	200	250	350
Expansion tank	Each	60	80	100
Insulation	--	500	750	1000
DHW Preheat tank	Each	80	100	150

INSTALLATION TIME ESTIMATES FOR TYPICAL LIQUID-HEATING SYSTEMS

ITEM	UNIT	TIME (MAN-HOURS)		
		LOW	MEDIUM	HIGH
Collectors and flashing	400-500 ft^2	40	60	80
Storage tank	Each	8	10	12
Piping loops	All	40	60	80
DHW preheat subsystem	--	8	12	20
Insulation	All	16	20	30
Controls	--	8	12	16
Testing and balancing	--	10	15	20

Table 15-3

Typical Equipment and Material Prices (in 1978) for Air-Heating Systems

Item	Unit	Price Range (in dollars)		
		Low	Medium	High
Flat-plate collectors and mounting hardware	ft^2	10	15	24
Storage containers	ft^3	0.5	1	1.5
Gravel	ton	3	4	5
Blower and motor	each	150	175	200
Control and sensors	set	500	750	1500
Motorized dampers	each	115	125	150
Heat exchanger	each	45	60	80
DHW Preheat tank	each	80	100	150
Ducts	bulk	2000	2500	3500
Insulation	bulk	500	750	1000
Miscellaneous	-	200	300	400

Table 15-4

Installation Time Estimates for Typical Air-Heating Systems

Item	Unit	Time (man-hours)		
		Low	Medium	High
Collectors	400-500 ft²	40	60	80
Storage unit	each	20	25	30
Ducting	all	50	75	100
Controls	-	8	12	16
DHW preheat subsystem	-	8	12	20
Insulation	-	16	20	30
Testing and balancing	-	10	15	20

Table 15-5

Equipment Costs for Components of Domestic Water Heaters (1978 prices)

Item	Unit	Price Range (in dollars)		
		Low	Medium	High
Flat-Plate Collectors and mounting hardware	ft²	10	15	24
Preheat tank	80-gallon capacity	100	200	250
Pump and motor assembly	each	80	120	150
Heat exchanger	each	200	300	400
Controls and sensors	set	100	150	200
Piping (1/2 inch copper)	ft	.40	.50	.75
Valves	each	20	30	45
Miscellaneous fittings	bulk	30	40	50
Expansion tank	each	60	80	100
Insulation	bulk	80	100	120

Table 15-6

Estimates of Installation Times for Domestic Water Heaters

Item	Unit	Time (man-hours)		
		Low	Medium	High
Collectors and flashing	2-4 collector units	4	8	12
Preheater tank	1	1	2	2
Piping loops, pumps, valves	all	8	12	16
Insulation		2	4	6
Controls	-	1	2	3
Filling, testing, and adjusting	-	2	4	6
For packaged units, subtract 20 percent from total	Total (with 20% subtracted)	14	26	37

Maintenance and Insurance Costs

In a present-value model, level yearly recurring costs are brought to a present value by multiplying the amount in the base year by the uniform present value factor, UPV, provided the analysis is in constant dollars and uses a real discount rate. If the analysis is in nominal dollars and uses a nominal discount rate, it will be necessary to multiply base-year costs by the modified version of the UPV, incorporating the projected inflation rate.

No adjustment to the base-year costs is needed for an annual-value model. The base-year values can be interpreted as uniform annual values in constant dollars.

Maintenance and insurance costs are often treated as yearly recurring costs, remaining unchanged in constant dollars. Alternatively, these costs, particularly maintenance costs, may be projected to change in real terms, because of deterioration over the life of the system. If the projected change is at a constant rate, the modified UPV can be used to convert to a present value. If the rate of change is not constant, these costs are usually treated as nonrecurring costs.

If additional insurance costs are incurred on the solar energy system, they should be considered in the life-cycle cost analysis. In so doing, it is important to remember that insurance costs represent a tradeoff to the homeowner for incurring damage costs. It is the net cost to the homeowner of damage, I_n, which is relevant, that is, the cost of insurance (insurance premiums) plus damage losses, net of insurance reimbursements collected. The net cost in annual-cost terms is as follows (ref 8): $I_n = I + L - C$

where: I is annual insurance premiums,
L is annual damage loss,
C is annual insurance reimbursements.

Energy Savings

If a yearly recurring cash flow, e.g., energy savings, is projected to change at a constant rate over some period of time, the modified uniform present value factor, UPV, for the appropriate period of time can be multiplied by the base-year amount in order to determine the equivalent present value. To determine the equivalent annual value, it is necessary first to find the present value incorporating the price escalation, and then to apply the unifom capital recovery factor, UCR, to the present-value amount. The projected rate of future price escalation can also be changed over time.

Replacement Costs and Salvage Value

Cash flows that do not recur annually, such as repair and replacement costs and salvage values, can be converted to a present-value by applying to each item the single-present-value factor, SPV, appropriate to the year in which the cash flow occurs. Nonrecurring cash flows can be converted to an annual value by applying the uniform capital recovery factor, UCR, to the present-value amount.

Property Taxes and Income Taxes

The effect of taxation on the costs of a solar system to the owner may be considered for two main cases:
1. for the owner-occupied solar residence, and
2. for the rental solar residence or other solar commercial buildings.

For both cases, taxes impact on costs in several ways, in some instances raising and in other instances lowering life-cycle costs of the solar heating, ventilation, and air-conditioning (HVAC) system relative to its conventional counterpart. Let us examine the two cases in turn for tax implications.

Owner-occupied residence: For the owner-occupied residence, the primary tax effects are from the property tax and, indirectly, from the income tax. The particular effect of either of these taxes could be expected to vary among individual solar residences, depending upon local property-tax rates, property assessment practices, and the income-tax bracket of the homeowner. The focus here is on the nature of the effects and on the method of including them in the life-cycle cost analysis.

The property tax, which is levied as a percentage of a fraction of the market value of a building, would tend to raise the life-cycle costs of a solar HVAC system relative to a conventional system. Life-cycle costs would be raised because, other things equal, the greater first cost of solar HVAC equipment would be reflected in a higher market value for the residence, and hence in a larger assessed value for the solar residence than for a conventional residence with its lower first-cost HVAC system. Thus, the capital intensiveness of an HVAC system influences the amount of property taxes levied on a residence, and thereby alters the life-cycle cost of the HVAC system.

As a simple example, let us compare the property tax on a \$60,000 solar residence, of which \$8000 is attributable to additional cost of the solar HVAC system, with a counterpart conventionally heated and cooled home valued at \$52,000 (i.e. \$60,000 - 8000). Given a typical tax rate of 4.50 percent of

50 percent of market value, the \$60,000 solar residence would be assessed at \$30,000 and taxed \$1350. The counterpart conventional home would be assessed \$26,000 (i.e.,50 percent of \$60,000 - \$8000) and taxed \$1170. For purpose of illustration, further assume a real discount rate of 2 percent, a constant real property value (including a constant real value for the solar system with replacements made as needed), and a constant property tax rate over a 20-year period of evaluation. (The assumption of a constant real property value and a constant property tax rate means that even though the nominal, or market, property value changes, the yearly property tax remains constant in terms of present prices.) Over 20 years, the property tax on the solar residence would amount in present-value terms to \$22,074-i.e., $\$1350\ [(1 + 0.02)^{20} - 1]/[0.02(1+0.02)^{20}] = \$22{,}074$: the present value of the property tax on the conventional residence would amount to \$19,131-i.e., $\$1170\ [(1 + 0.02)^{20} - 1]/ 0.02 (1+ 0.02)^{20}] = \$19{,}131$. Thus, the effect of the property tax in the above example is to raise the life-cycle cost of the solar residence relative to the conventional system by nearly \$3000. This simple illustration indicates that the property tax provides a disincentive for choosing solar HVAC systems.

In the example a constant real property value was assumed for ease of illustration. This assumption implies no real depreciation of the system over time during which necessary replacement of parts is made: i.e., the salvage value, in real terms, is assumed equal to the original first cost. In some cases this assumption might be reasonable. An alternative assumption is that the HVAC system (with parts replacements) depreciates in real terms from the time of purchase, so that little or no real value remains after, say, 20 years. Yet another possible assumption is that the assessed value of the system simultaneously reflects inflation and deterioration. This third assumption is described by the following equation:

$$PV_t = \sum_{j=1}^{n} \frac{tG_j}{(1 + i)^j} (1 - \bar{t})$$

where t = the property tax rate
$\bar{t}$ = the income tax rate
G_j = the assessed value of the HVAC system in year j in present dollars

The present value, or, depending on the model, the annual value, of the property taxes would be computed and added to other costs. This formula would cover both the case of a constant real assessed value for the HVAC system and the case of changing real assessed values over time.

The income tax, in contrast to the property tax, would tend to reduce the life-cycle cost of a solar vis-a-vis a conventional residence in two ways. For one thing, the homeowner is able to deduct solar mortgage interest payments from taxable income.

The higher first cost of the solar HVAC system, by increasing the size of the mortgage to be amortized, raises interest payments, the higher interest payments can then be deducted from income for purpose of computing income tax. The value of the tax deduction depends on the homeowner's personal income-tax bracket. Consider, for purpose of illustration, the case of a solar HVAC system whose first cost of, say, \$8000 comprises part of the homeowner's mortgage. With a 10 percent market rate of interest on the residential mortgage, the \$8000 amoritized over 20 years would add approximately \$940 per year to the mortgage payment. (For simplicity let us assume yearly mortgage payments rather than monthly payments.) The addition to the yearly payment is fixed at \$940 over the 20 years, and interest comprises a declining portion of the payment over time. In the first year, interest amounts to \$800(i.e., \$8000 x 0.10= \$800), and the principal is reduced by \$140 (i.e., \$940 - \$800 = \$140). In the second year, interest is \$786 [i.e., (\$8000-\$140) 0.10 = \$786], and the principal is reduced by \$154 (i.e., \$940- \$786 = \$154). Thus in the first year, the solar system would result in additional interest deductions from taxable income of \$800 and, if the homeowner is in a 25 percent income-tax bracket, the end-of-year value of the deduction would be \$200 (i.e., \$800 x 0.25 = \$200). At a 2 percent real discount rate, the present value of this savings would be \$196 [i.e., \$200/ $(1 + 0.02)^1$=\$196]. In the second year, the present-value return from the income-tax deduction would be \$189 [i.e., (\$786 x 0.25)/$(1 = 0.02)^2$ = \$189]. Over the full 20 years, the present value of the interest deductions, PV_I, would be calculated generally as:

$$PV_I = \sum_{j=1}^{n} \frac{\bar{t}(L_j m)}{(1 + i)^j}$$

where: $\bar{t}$ = personal income-tax rate

L_j = the additional mortgage loan principal outstanding in period j, i.e., that part associated with the HVAC system

m = the market rate of interest on the mortgage

(During a period of price change, it would be necessary to apply a price index to the amount of the tax deductions to convert them to constant prices or to use a nominal discount rate. This conversion of current dollars to real terms would be necessary because the tax deductions are fixed, and do not reflect changing prices.) To account for the effect of tax deductions of interest, the present value is subtracted from the homeowner's life-cycle costs.

In conclusion, property taxes tend to increase the homeowner's cost for a solar system relative to a counterpart conventional system because of the greater capital-intensiveness of the typical solar system. Income-tax effects, on the other hand, tend to reduce the relative costs of the typical solar syste, principally because of deduction from the homeowner's taxable income of interest payments which are larger for more capital-intensive systems.

Commercial and Industrial Buildings: Let us now consider the tax effects on the life-cycle cost of a commercial building equipped with a solar HVAC system, as compared with a commercial building equipped with a conventional HVAC system. In the case of commercial use of solar energy systems, the previously described property tax and income tax effects would also apply. The institutional treatment of property tax and interest charges would be somewhat different for commercial buildings than for owner-occupied houses in that these items of cost would be deductible as business expenses. The effect on costs, however, would be described by the same mathematical expressions developed above. There are, in addition, other income-tax-deductible expenses to consider in evaluating the commercially used system, such as depreciation deductions and deductions of operating (including energy) and maintenance expenses. Also, after-tax rental incom e of commercial buildings may be influenced by the choice between solar and conventional HVAC systems, and therefore, may need to be considered.

The larger capitalized value of a solar energy system would result in increased deductions of depreciation from taxable income. For example, for a straight-line method of depreciation, a first cost of \$8000 for the solar system, a 20-year life, and no salvage value, the annual depreciation deduction would be \$400. The present value to the building owner of the \$400 depreciation in a given year may be found by applying the owner's income tax rate to the \$400, and discounting that amount to the present. If inflation is present, the \$400 must first be converted to constant dollars before discounting. Alternatively, a depreciation method might be used which does not yield equal yearly amounts in either real or nominal terms (e.g., a declining balance method). A general expression of the present value of the tax deduction resulting from depreciation, PV_d, is:

$$PV_d = \sum_{j=1}^{n} \frac{D_j \bar{t}}{(1+i)^j}$$

where: D_j = depreciation in year j, in present dollars

$\bar{t}$ = building owner's income-tax rate.

On the other hand, a solar energy system might mean lower operating (fuel) costs than its conventional counterpart. Because of the attendant decline in tax-deductible expenses, tax deductions for operating costs would tend to be lower for a solar system than for its conventional counterpart.

Because of the time value of money, the present value of depreciation expenses is less than the present value of the capital expenses upon which it is based. In contrast, the present value of the deductible operating expenses is approximately equal to the corresponding operating expenses incurred. Consequently, if present-value capital costs are substituted (traded off) for present-value operating costs on a dollar-for-follar before-tax basis, there will not be a corresponding-dollar-for-dollar tradeoff on an after-tax basis. Rather, the present value of after-tax capital costs will increase relatively more than operating costs decline, and after-tax totalcosts will, therefore, rise as a result of the more capital-intensive system. Hence, the fact that operating costs afe fully deductible as a current business expense, while capital costs are deductible only as a depreciation expense, may in some cases bias building owners towards relatively less capital-intensive conventional HVAC systems over solar energy systems.

In most cases, it will probably be reasonable to assume that there are equal private benefits for the solar energy system and the conventional counterpart to which it is compared. However, in the case of some rental properties, particularly low-density rental residences, it may be necessary to take into account possible differences in rental revenue. Where conventionally provided utilities are paid by the tenant, rental revenue should be expected, other things equal, to be higher on a solar residence than on a comparable conventionally equipped residence. That is, the owner of a solar rental residence would incur the costs of solar equipment that would be reflected in higher rent but lower utility bills to the tenant. The owner of the rental solar residence would require higher rental payments to cover higher capital costs. If other things are equal and the market is functioning well, tenants should be willing to pay an additional amount of rent up to the amount of the additional utilities outlay which they would incur in a counterpart conventionally equipped residence (i.e., an amount sufficient to equalize the life-cycle costs to the tenants of counterpart solar and conventional rental units).

Different amounts of benefits (i.e., rental income) for buildings equipped with different HVAC systems mean that benefits of the alternative systems are unequal. To compare the alternative systems, differences in their benefits as well as in their costs should be evaluated. Inequalities in benefits can be treated in the present-value and annual-cost equations as negative costs, by entering, in this case as a negative cost, any additional after-tax rental income generated by the rental solar residence over the conventional counterpart. Annual after-tax rental income Y_r would be expressed as:

$$Y_r = (1 - \bar{t})Y$$

where Y = additional annual gross rental revenue for a solar residence over its counterpart conventional residence

$1-\bar{t}$ = the factor applied to obtain after-tax income. This additional amount of annual income, i.e., $(1-\bar{t})Y$, would be converted to present value and subtracted from life-cycle costs.

Government Incentives

Effective life-cycle costs to owners and users of solar-equipped buildings may be further changed by governmental programs designed to encourage adoption of solar HVAC systems. These programs might offer special incentives for solar systems in the form of tax credits, low-interest loans, or direct grants or subsidies to manufacturers and/or buyers of solar HVAC systems. Alternatively, incentives for solar energy systems might be provided in the form of penalties applied to conventional HVAC systems such as taxing conventional HVAC systems more severely than solar systems. In either case, if the comparative cost to the homeowner is altered by special programs, the cost evaluation should reflect the induced changes.

The method of treating the cost effects of such programs would vary. Subsidies to producers of solar systems, for example, might be reflected in the lower purchase price of the systems, and no additional expression need be introduced into the life-cycle cost model in order to assess this effect. On the other hand, a subsidy to the purchaser of a solar energy system, say, in the form of a low-interest loan for the purchase of a solar home, might require specific evaluation of the interest subsidy, including income tax effects.

Some programs intended to provide incentives for purchase of solar energy systems may do this by reducing previously existing disincentives for solar energy. For example, some states and localities are exempting some part of the first cost of a solar energy system from the property tax (e.g., in Colorado, the law requires that solar systems be assessed at 5 percent of their market values).

Following are seven types of financial incentive policies that appear to be the principal types of incentives under consideration both at the state and federal levels:
1. Direct grant
2. Income-tax credit
3. Property-tax reduction
4. Sales-tax reduction
5. Income-tax deduction for depreciation
6. Loan-interest subsidy
7. Tax on conventional energy

Each of these is briefly described and discussed in turn.

The first type of incentive listed, i.e., a direct grant to the purchaser of a solar energy system, is being used in conjunction with federal programs as well as by a number of states. The Solar Demonstration Program (1974-79), administered by the U.S. Department of Housing and Urban Development (HUD), provided grants for the installation of solar units in new and existing dwellings. Grants can be treated in the evaluation model as a negative first cost.

The second type of incentive listed, i.e., the income-tax credit, involves the reduction of the recipient's income-tax liability by a specified amount. Aside from slight differences in timing, the income tax credit is essentially the same as a direct grant, as long as the credit is reimbursable (i.e., the recipient receives any excess of the tax credit over the amount of income-tax liability). For example, suppose a tax credit of $2000 is allowed to the purchaser of a solar energy system whose personal income-tax liability is only $1500. If the purchaser receives a check for $500, in addition to the waiver of income taxes owed, the purchaser will have the equivalent of a cash payment of $2000 received at that time. Extension of the investment -tax credit to cover solar energy equipment installed in commercial buildings is also a type of tax-credit incentive.

The third type of incentive, i.e., the reduction in property taxes, appears to be the most prevalent form of direct financial incentive now being enacted at the state level.

The fourth type of incentive, i.e., the reduction in the sales tax on solar energy equipment, is less frequently used.

The fifth type of incentive, i.e., the allowance of an income-tax reduction for depreciation on the capital costs of solar energy systems, can take several forms. One approach is to expand the current eligibility for capital depreciation deductions from businesses to include homeowners. Another approach is to increase the value of the depreciation, either by shortening the length of time over which the depreciation is written off against yearly tax liability, or by otherwise allowing a more liberal depreciation method. The value of the write-off is increased by shortening the defined life of the system or by using a depreciation method which results in larger deductions initially because the tax savings are thereby obtained more quickly and can be put to profitable use.

The sixth type of incentive is a subsidy to reduce the interest rate charged on loans to purchase solar energy systems. The after-tax value of this incentive may be substantially less than the before-tax value.

The seventh incentive is the imposition of a special tax on conventional energy sources. Because solar energy systems derive their economic value from the cost of alternative sources of energy, raising the price of the alternative sources (e.g., by imposing a new tax or by raising existing taxes) will increase the value of solar energy.

NON-LIFE-CYCLE-COST EVALUATION METHODS

The methods of economic evaluation encompass a wide range of options depending upon the cash flow components and the period to be considered in any specific analysis. The various methods can be conveniently separated into two groups: (1) those which evaluate on the basis of life-cycle costing, and (2) those which do not. The latter methods will be introduced first.

Breakeven Cost

One simple method to assess the economic competitiveness of a solar system with a conventional system, is to compare the costs of delivered energy. If the solar and conventional enregy costs are equal, they are said to "break even". In breakever calculations a uniform annual cost is applied, and in simplest terms, inflation and discount rates are ignored. Usually, the uniform annual cost of the solar system is considered to consist of annual mortgage repayment (principal plus interest) and operating costs. More complex breakeven analysis could include other annual costs such as property taxes, insurance, and maintenance, minus an annual credit for income tax saving on interest paid on the mortgage. The simple calculation assumes that property taxes, insurance, and maintenance costs are offset by an annual income tax credit on the interest paid (at least in the first few years).

Example of Breakeven Cost

Problem: A solar heating system with 300 ft^2 of collectors costs $12,000 ($40/ft^2). After taking a Federal income tax credit of $4000 and state income tax credit of $1000, a 30-year loan is negotiated for $7000 at 10 percent interest. The solar system will provide an annual average useful thermal energy of 50 million Btu. Determine a (simple) breakeven cost for the solar system.

Solution: At 10 percent interest, a 30-year loan will necessitate a uniform annual payment of $743 to repay the $7000 loan. With a net useful annual solar thermal energy delivery of 5- MMBtu, the solar energy cost is $14.86/MMBtu, and breakevern prices of conventional fuels are:

TYPE OF FURANCE	BREAKEVEN PRICE
Electric Resistance	5.1¢/KWh
Oil furnace at 60% efficiency (140,000 Btu/gal)	$1.25/gal
Propane furnace at 70% efficiency (90,000 Btu/gal)	$0.94/gal
Natural gas furnace at 70% efficiency (1000 Btu/ft^3)	$1.04/100 ft^3

Payback Evaluation

Another widely used method of evaluation, the payback method, does not take into account costs and savings over the life of an investment, and, therefore, is not in a strict snese a life-cycle costing method. In the case where a fast turnaround on an investment is required (for example, to repay a short-term loan), the payback method may provide useful information. This evaluation method measures the elapsed time between the point of an initial investment and the point at which accumulated savings, net of post-investment accumulated costs, are sufficient to offset the initial investment.

The calculations may be made with or without consideration to escalation of energy prices and market discount rate. If inflation and discount rates are ignored, the result of the calculation is called simple payback (SPF) period. If inflation and discount are both considered, a discounted payback (DPF) period can be determined.

Simple Payback Method

In equation form, simple payback period may be calculated as follows:

$$\text{SPB (years)} = \frac{\text{System Cost}}{\text{(Annual Energy Costs Savings-Annual O* and M* Costs}}$$

(*O and M are operating and maintenance)

Example of the Simple Payback Method

Problem: Determine the simple payback period for solar aystem with a net investment cost (after tax credits) of \$8000 which delivers 80 million Btu of useful solar erngy annually. The annual operating and maintenance costs total \$172, and the conventional fuel displaced is electricity at 5¢/KWh. Determine also the discounted payback period if the fuel inflation rate is 15% and discount rate is 10%.

Solution: The annual energy cost savings are:

$$\frac{80 \times 10^6 \text{ Btu}}{3413 \text{ Btu/kWh}} \times \frac{\$0.05}{\text{kWh}} = \$1172.$$

The operating cost is computed on the basis of 7% operating energy requirement and a small amount is added for maintenance to total \$172. Then the simple payback period is:

$$\text{SPF} = \frac{8000}{1172 - 172} = 8 \text{ years}$$

Discounted Payback Method

Discounted payback period is the period between initial investment and the time when net energy savings, appropriately inflated and discounted, equal the initial investment.

The algebraic expression for determinging discounted payback is the following:

$$\Delta I + \left[\sum_{k=1}^{H} \sum_{j=1}^{Y} (P_k \Delta Q_k \, b^j) + \sum_{j=1}^{Y} a^j (\Delta M_j + \Delta R_j) \right] = 0$$

where: I = total first costs associated with the energy system, including design, purchase, installation, building modification, and the value of useful building space lost;

P_k = the initial price of the kth type of conventional energy for energy types $k = 1$ to H;

Δ = change attributable to solar energy;

Q_k = the quantity required of the kth type of conventional energy (equipment efficiencies should be taken into account in calculating Q_k);

$b^j = (1 + e_k)/(1 + d)^j$ = a formula for finding the present value of an amount in the jth year, escalated at a rate e_k, where k denotes the kth type of energy;

$a^j = (1 + d)^{-j}$ = the single-present-value formula computed for a designated year from from $j = 1$ to Y and discount rate d;

Y = the number of years to pay back when cash flows are discounted;

M_j = maintenance costs in year j;

R_j = repair and replacement costs in year j.

If the net savings are constant S, $Y = -\ln(1 - iI/S)/\ln(1 + i)$ where i is the compound rate of interest.

Example of Discounted Payback

The table on next page shows the payback period calculated for the hypothetical investment problem used to illustrate the life-cycle cost methods. Cumulative discounted savings and recurring costs are compared in each year with the initial investment cost, until net savings become positive. With energy prices escalated at a rate of 5 percent and discounted at a rate of 10 percent, energy savings are shown to offset investment costs in the seventh year.

Illustration of Discounted Payback Method*

Years into the investment (1)	Amount of initial investment cost, dollars (2)	Present value of cumulative energy savings, † dollars (3)	Present value of other cumulative costs (4)	Present value of net savings ‡ dollars (5)
1	8000	1432	0	-6568
2		2799	0	-5201
3		3103	0	-4897
4		5348	0	-2652
5		6537	0	-1463
6		7672	0	- 328
7		8755	0	+ 755

* Based on hypothetical cost data and assumptions presented in the discussion of life-cycle cost emthod, and derived by the discounted payback equation.

† Derived by applying to the base-year energy savings of $1500 the uniform-present-value factor for each successive year, including a factor for energy price escalation.

‡ Net savings is the difference between the initial investment cost and the cumulative present value of savings less recurring costs.

Advantages and Disadvantages of Payback Methods

The payback method has the principal advantages of being easy to understand and familiar to a wide audience. Its appeal also lies in the fact that it allows emphasis to be given to the rapid recovery of investment funds, an objective important to many organizations. Rapid payback is often of critical improtance to speculative investors. It can also be important to other investors if financial resources are available for only a short period of time or if there is considerable doubt as to the expected life or resale value of the major components of the investment. Often, however, there is too much emphasis on the length of the payback period, and not enough emphasis on overall expected profitability of the investment.

A principal disadvantage of the payback method is that even if based on discounted cash flows, it does not provide a comprehensive evaluation of an investment's profitability. It is not comprehensive because it does not include those cash flows that occur after the point payback is reached. The case is sometimes made that this shortcoming can be overcome by comparing the expected life of the major components of an investment with the estimated payback period to determine how long savings are expected to continue beyond the point that costs are recovered. And, with very simple investment problems involving uncomplicated patterns of costs and savings, this comparison can usually be made.

However, even in the simple case the payback method provides no clear, reliable measure of overall economic performance for comparing alternative investments. Comparison of alternatives strictly on the basis of the payback period may lead to inefficient investment decisions, because an investment with a longer payback may be more profitable than an investment with a shorter payback.

LIFE-CYCLE COSTING METHODS

When investment costs are high and resulting dollar benefits (savings) are distributed and changing in amount over time--as they are for most applications of solar energy--it is reasonable to make thorough comparisons of lifetime costs and savings before undertaking an investment. "Life-Cycle costing" is a method of economic evaluation that is generally appropriate for evaluating an investment whose principal benefits occur in the form of cost savings.

Although the term life-cycle costing is used to refer to a specific method of measuring economic performance, it is also often used in a broader sense to refer to any of several widely used, comprehensive methods that evaluate all significant costs and benefits (savings) over the relevant period of time, taking into account the time value of money. These include the net benefits (or savings) method, the benefit/cost (or savings-to-investment) ratio method, and the internal rate of return method. The evaluation methods differ essentially in the manner in which they relate costs and savings.

For example, the life-cycle cost method, used to refer to a specific evaluation method, means the summing of acquisition, maintenance, repair, replacement, and energy costs over the life of the investment. The investment that has the lowest total life-cycle cost while meeting the investor's objectives and constraints is the preferred investment.

The net benefits method, as applied to solar energy, finds the difference between the lifetime dollar energy savings from an investment in solar energy and its lifetime dollar costs. A positive dollar value means the investment is profitable, and a negative value indicates losses.

The benefit/cost (or savings-to-investment) ratio method expresses savings, net or recurring costs, from solar energy as a numerical ratio to investment costs. The higher the ratio, the more dollar savings that are realized per dollar of investment cost.

The internal rate of return method finds the interest rate for which lifetime dollar savings are just equal to the lifetime dollar costs. This interest rate indicates the rate of return on the investment. The rate of return is then compared to the investor's minimum acceptable rate of return to determine if the investment is desirable.

Although these evaluation methods are closely related to one another, they are not necessarily substitutable methods for dealing with differenct types of investment decisions. For some types of decisions, the choice of a method is more important than for others. The choice of method is not usually critical, for example, in simple "accept-reject" investment decisions, in that any of the above life-cycle cost methods, used correctly, will indicate if an investment in solar energy will save more than it costs.

The choice of method is important for determining the economically optimal size of a solar energy system. For this type of decision, the life-cycle cost method or the net benefits method is recommended over the other methods because either of these two methods will indicate very directly the optimal system size. As long as the total cost of a building is reduced or the net savings from an investment is increased by adding to the capacity of the solar energy system, it pays to do so.

For allocating a limited budget among available investment opportunities, the benefit/cost (savings-to-investment) ratio method or the internal rate of return method is recommended, because the use of either of these methods will result in the selection of investment projects with the largest total return for a given investment budget.

Life-Cycle Cost Method

This evaluation method calculates either the total present value or the total annual value of the lifetime dollar costs associated with each alternative energy system under consideration. The alternative with the lowest cost is more economical, provided it meets other requirements of the investor.

Present Value of Life-Cycle Costs

Following is a formula for calculating, in present-value dollars, the total life-cycle costs a PV associated with owning and operating any energy system:

$$PV = I - (V_n a^n) + \sum_{j=1}^{h} a^j (M_j + R_j) + \sum_{k=1}^{h} \sum_{j=1}^{h} P_k Q_k b^j$$

Where: PV = total present-value, life-cycle costs, before taxes, associated with a given energy system;

I = total first costs associated with the energy system, including design, purchase, installation, building modification, and the value of useful building space lost;

V_n = residual or salvage value at year n, the last year in the evaluation;

a = the single-present-value formula computed for a designated year from j = 1 to n and discount rate d; i.e., $a^j = (1 + d)^{-j}$;

M_j = maintenance costs in year j;

R_j = repair and replacement costs in year j;

P_k = the initial price of the kth type of conventional energy for energy types k = 1 to H;

Q_k = the quantity required of the kth type of conventional energy (equipment efficiencies should be taken into account in calculating Q_k);

b^j = a formula for finding the present value of an amount in the jth year, escalated at a rate e_k, where k denotes the kth type of energy, and discounted at a rate d; i.e., $b^j = [(1 + e_k)/(1 + d)]^j$.

Example of the Life-Cycle Cost Method in Present-Value Dollars

Table 28.1 illustrates in a simple example the use of the life-cycle costing method to compare two alternative energy systems: (1) a combined solar and conventional energy system, and (2) a conventional energy system used alone. The total costs were calculated from the equation for present value of live-cycle costs.

TABLE 28.1 Illustration of the Life-Cycle Costing Method in Present-Value Dollars[a]

Type of energy system (1)	Period of analysis, years (2)	Initial investment cost, dollars (3)	Base-year energy costs, dollars (4)	Present value of energy costs,[b] dollars (5)	Replacement costs, dollars (6)	Present value of replacement costs,[c] dollars (7)	Salvage, dollars (8)	Present value of salvage,[d] dollars (9)	Present value of total costs,[e] dollars (10)
Solar/conventional auxiliary	20	20,000	500	6359	0	0	0	0	26,359
Conventional	20	12,000	2000	25,435	6000/15th year	1436	4000/20th year	594	38,277

[a] All costs are evaluated with a discount rate of 10%, a fuel price escalation rate of 5%, an investment horizon of 20 years, and the assumption that the solar energy system has no value remaining after 20 years, and the conventional system has a salvage value of two-thirds of the cost of the replacement.

[b] Derived using the uniform-present-value formula including a factor for fuel price escalation, for a discount rate of 0.05, and 20 years; i.e.,

$$\$6359 = \$500 \sum_{j=1}^{20} \left(\frac{1 + 0.05}{1 + 0.10}\right)^j$$

$$\$25,435 = \$2000 \sum_{j=1}^{20} \left(\frac{1 + 0.05}{1 + 0.10}\right)^j$$

[c] Derived using the single-present-value factor for a discount rate of 0.10 and 15 years; i.e., \$1436 = \$6000 (0.2394).

[d] Derived using the single-present-value factor for a discount rate of 0.10 and 20 years; i.e., \$595 = \$4000 (0.1486).

[e] Derived by summing the present value of investment costs, energy costs, and replacement costs less salvage value; i.e., col. 10 = col. 3 + col. 5 + col. 7 − col. 9.

The combined solar/conventional energy system is assumed to cost \$20,000 or \$8000 more than the conventional system alone (col.3) The major components of the combined system are expected to last 20 years, as compared with 15 years for the conventional system alone. Setting the period of analysis at 20 years for both systems (col.2) means that the conventional system will be due for a major replacement (assumed to cost \$6000) at the end of the 15th year (col.6), of which two-thirds of the value is assumed to remain at the end of the 20th year (col.8). The combined system will require no replacements and is assumed to result in substantial fuel savings, reducing annual energy costs from \$2000 to \$500, valued in base-year dollars (col.4). On the basis of an expected fuel price rise of 5 percent per year and a discount rate of 10 percent, the present value of energy costs for the combined system equals \$6359 (col.5), and its total life-cycle cost equals \$26,359 (col.10). For the conventional system alone, the present value of energy costs is \$25,435 (col.5), the present value of replacement cost equals \$1436 (col.7), the present value of the salvage value equals \$594 (col.9) and total life-cycle cost equals \$38,277 (col.10). Hence, over 20 years the total life-cycle cost of the combined system is \$11,918 less than the cost of the conventional system and is, therefore, the preferred investment.

Annual Value of Life-Cycle Costs

An alternative to expressing life-cycle costs in present-value terms is to express them in annual-value terms, that is, as a stream of level annual costs extending over a period equal in length to the period of analysis. The measure of annual value may be derived directly from the measure of present value by applying the uniform capital recovery factor. Expressed in annual-value terms, the life-cycle cost method is used exactly as in present value life-cycle cost analysis to find the lowest-cost alternative for accomplishing a given objective.

A formula for finding the total annual value AV of life-cycle costs of an energy system is:

$$AV = c \times PV$$

Where: AV = total annual-value life-cycle costs associated with a given energy system;

c = the uniform capital recovery formula, $i/\left[1 - (1 + i)^{-n}\right]$;

PV = total present-value, life-cycle costs, before taxes, associated with a given energy system.

Example of the Life-Cycle Cost Method in Annual-Value Dollars

Table 28-2 illustrates the evaluation of the life-cycle cost of an investment in annual-value dollars. The present value of the total life-cycle costs of the two energy systems derived in Table 28.1 are here converted to annual-value equivalents using the equation for annual value of life-cycle costs.

TABLE 28.2 Illustration of the Life-Cycle Costing Method in Annual-Value Dollars[*]

Type of energy system (1)	Period of analysis (2)	Present value of total costs, dollars (3)	Annual value equivalent of total costs,[†] dollars (4)
Solar/conventional auxiliary	20	26,359	3097
Conventional	20	38,277	4498

[*] Based on the hypothetical cost data and assumptions given in Table 28.1.

[†] Derived by Eq. (28.1), i.e., \$3097 = \$26,359 (0.1175), \$4498 = \$38,277 (0.1175), where 0.1175 is the uniform capital recovery factor for a discount rate of 10% and 20 years.

In annual-value dollars, the combined solar/conventional energy system costs \$3097 (as compared with the present-value equivalent of \$26,359); the conventional system alone costs \$4498 in annual-value dollars (as compared with the present-value equivalent of \$38,277); and the combined system is shown again to be the least-cost system.

Life-Cycle Cost Per Unit of Energy

A slightly different way of using the life-cycle cost method to evaluate an investment in solar energy is to calculate and compare in annual-value dollars the life-cycle cost per unit of energy delivered to a building by alternative energy systems. If the assumptions are made that the conventional heating and cooling system is identical whether or not a solar energy system is added, and that the price of conventional energy per unit purchased is constant with respect to the quantity purchased, the calculations are simplified. In this case, the cost comparison can be made by first finding the life-cycle costs in annual-value dollars of the solar energy system, and dividing this by the amount of energy expected to be supplied by the solar energy system each year. That is, the life-cycle cost in annual-value dollars of a unit of energy provided by solar, US, may be calculated as follows:

$$US = AV_S/SES$$

Where: US = the unit life-cycle costs in annual-value dollars of solar energy;

AV_S = total life-cycle costs in annual-value dollars of the solar energy system;

SES = amount of solar energy supplied annually, expressed in some unit of measure such as joules/year or Btu/year.

The next step is to derive the per-unit cost of supplying a unit of heating or cooling by conventional energy, UC. This may be found by the following equation:

$$UC = \frac{SP_c}{COP} \sum_{j=1}^{h} b_c^j + \frac{HP_h}{F} \sum_{j=1}^{h} b_h^j \quad c$$

Where: UC = per-unit cost of supplying conventional energy, after the heating and/or cooling plant is in place;

S = energy for cooling as a fraction of total annual energy requirement;

P_c = purchase price per unit of energy for cooling (units should be consistent with the units in which solar energy costs are measured);

COP = coefficient of performance of cooling equipment;

b_c^j = a factor for finding the present value of the price per unit of cooling energy in the jth year when it is escalating at a rate e_c:

$$b_c^j = (1 + e_c)/(1 + i)^j$$

H = energy for heating as a fraction of total annual energy requirements;

P_h = purchase price per unit of energy for heating;

F = efficiency of the heating furnace expresses as a fraction;

b_h^j = a factor for finding the present value of the price per unit of heating energy in the jth year when it is escalating at a rate e_h:

$$b_h^j = (1 + e_h)/(1 + i)^j;$$

c = the uniform capital recover factor: $c=i/\ 1-(1+i)^{-n}$.

By comparing the life-cycle cost in annual-value dollars of a unit of energy supplied by the solar energy system, US, with the unit cost of conventional energy, UC, the type of energy with the lowest life-cycle cost can be identified.

Example of the Life-Cycle Cost Per Unit of Energy Method

Table 28.3 illustrates the use of this method for evaluating the cost-effectiveness of the same solar energy system used in preceding examples. If it is assumed that 210 million Btu are supplied each year by solar energy (col.6) and that the life-cycle cost of the solar energy system in annual-value dollars is $841 (col.5), the equation for unit of energy provided by solar, US, can be used to derive the unit cost of solar energy. The life-cycle cost per therm (100,000 Btu) of solar energy supplied is found to be $0.40 (col. 7). This is lower than the cost per therm of $1.067 for conventional energy as derived by the equation for a unit of conventional energy, UC, (col. 8).

TABLE 28.3 Illustration of the Life-Cycle Cost Method to Compare the Unit Cost of Energy Supplied by Alternative Energy Systems[a]

Differential investment cost of solar, dollars (1)	Annual value of solar investment cost,[b] dollars (2)	Savings in replacement costs salvage, dollars (3)	Annual value of net replacement cost savings,[c] dollars (4)	Annual value of solar costs,[d] dollars (5)	Amount of solar energy supplied each year, Btu (6)	Annual cost per unit of solar energy supplied,[e] dollars (7)	Levelized unit cost of conventional energy,[f] dollars (8)
8000	940	6000/15 year 4000/20 year	99	841	21×10^7	$0.40/10^5$ Btu 4.00/MM Btu	$1.067/10^5$ Btu 10.67/MM Btu

a. Based on hypothetical cost data presented in Table 28.1 and derived by the equations for life-cycle cost per unit of energy. Additional assumptions are that the initial cost of the solar auxiliary system is equal to the cost of the conventional system used alone, that the conventional system lasts 5 years longer when used as an auxiliary, that the energy costs of the solar auxiliary system are $500, that the conventional system is powered by no. 2 fuel oil priced at $0.50/gal, and that the furnace efficiency is 0.5.

b. Derived using the uniform capital recovery factor for a discount rate of 10% and 20 years; i.e., $940 = $8000(0.1175).

c. Derived using the single-present-value factors for a discount rate of 10% and 15 years and 20 years and the uniform capital recovery factor for 20 years; i.e., $99 = $6000(0.2394) - $4000(0.1486) (0.1175).

d. Derived by the equation for annual value of life cycle costs, combining the annual value of investment cost and the annual value of net replacement cost savings; i.e., $841 = $940 - $99.

e. Derived by the equation for unit life-cycle cost of solar energy, i.e., $\$0.40/10^5\text{Btu} = \$841/21 \times 10^7$ Btu.

f. Derived by the equation for unit life-cycle cost of conventional energy; i.e.,

$$1.067/10^5 = (0.50/\text{gal}/0.5)\left[\sum_{j=1}^{20}\left(\frac{1 + 0.05}{1 + 0.10}\right)^j\right](0.1175)/(1.4\ \text{therm}/\text{gal})$$

Advantages and Disadvantages of the Life-Cycle Cost Method

This method is effective for determining if a solar energy system is expected to reduce the total life-cycle costs of the energy components of a building. It is also useful for determining the optimal sizing of a solar energy system, by showing the impact of changes in investment size on lifetime costs. If total life-cycle costs are lower with a solar energy system than with a conventional system alone, the solar energy system is cost-effective. As long as life-cycle costs continue to decline as the size of the solar energy system is increased, it pays to increase the size of the system, other things being equal.

Theoretically the size of a project should be increased only as long as the return at the margin on that investment is equal to or greater than the return at the margin on competing investments. However, as a matter of practice, individual projects are often sized (scaled) apart from consideration of other projects. Then projects of a predetermined design and size are compared with one another.

The life-cycle cost method is often used for overall comparisons of alternative building designs, for example, an energy-conserving design versus a more conventional design.

The life-cycle cost method, however, is not always effective for evaluating investments in solar energy relative to competing investments, because the method does not lend itself to ranking competing investments in terms of their economic efficiency. Although the life-cycle cost measure indicates whether total dollar owning and operating costs of a building are increased or decreased by an investment in solar energy, it does not indicate the return on the investment dollar.

Net Benefits Methods

The net benefits (savings) method is useful for converting the analysis of an investment such as solar energy, which largely involves costs, to a standard benefit-cost format involving both costs and savings. Lifetime costs are subtracted from lifetime savings to derive net savings from the investment. As in the case of computing total life-cycle costs, net savings may be expressed in either present-value or annual-value dollars.

The method involves the same cost elements and arrives at the same conclusion as the life-cycle cost method, but is formulated somewhat differently.

Present Value of Net Savings

A formula derived from the present value of life-cycle cost method by differencing for calculating net savings in present-value dollars, PNS, from a solar energy investment is:

$$PNS = \sum_{k=1}^{h} \sum_{j=1}^{n} \left[(P_k \Delta Q_k b^j)(-1) \right] - \left[(\Delta I - \Delta V_n a^n) - \sum_{j=1}^{n} a^j (\Delta M_j + \Delta R_j) \right]$$

Where: PNS = present value of net dollar savings;
Δ = change attributable to solar energy;

P_k = the initial price of the kth type of conventional energy for energy types k = 1 to H;

Q_k = the quantity required of the kth type of conventional energy (equipment efficiencies should be taken into account in calculating Q_k);

b^j = a formula for finding the present value of an amount in the jth year, escalated at a rate e_k, where k denotes the kth type of energy, and discounted at a rate d; i.e., $b^j = (1+e_k)/(1+d)^j$;

I = total first costs associated with the energy system, including design, purchase, installation, building modification, and the value of useful building space lost;

V_n = residual or salvage value at year n, the last year in the evaluation;

a = the single-present-value formula computed for a designated year from j=1 to n and discount rate d; i.e., $a^j = (1 + d)^{-j}$;

M_j = maintenance costs in year j;

R_j = repair and replacement costs in year j.

This formula allows for the evaluation of a solar energy plus auxiliary system in direct comparison with a conventional energy system. It calculates the net difference between the present value of energy savings due to the solar energy system and the differential investment, maintenance, repair, and replacement costs attributable to the solar energy system.

Example of the Net Benefits (Savings) Method in Present-Value Dollars

Table 28.4 illustrates this method in a simple example, based on the same costs and assumptions used in the example for the life-cycle cost per unit of energy. The solar energy system is assumed to cost \$8000 more than the conventional system, to save \$1500 annually in energy costs (valued in base-year dollars), and to last 20 years--5 years longer than the conventional system--without a major replacement. The present value of energy savings over the 20 years equals \$19,077 (col. 4). The present value of the savings in net replacement costs owing to the expected 5-year longer life of the conventional system when paired with a solar system equals \$841 (col.5). Net savings from the investment in solar energy are, therefore, \$11,919 (col. 6).

TABLE 28.4 Illustration of the Net Benefits (Savings) Method in Present-Value Dollars*

Period of analysis, years (1)	Differential solar investment costs, dollars (2)	Base-year energy cost savings, dollars (3)	Present-value energy savings,† dollars (4)	Present value of net replacement cost savings,‡ dollars (5)	Net present-value savings,§ dollars (6)
20	8000	1500	19,077	841	11,918

*Based on the hypothetical cost data and assumptions given in Table 28.1.

†Derived using the uniform-present-value formula including a factor for fuel price escalation; i.e.,

$$\$19{,}077 = 1500\,\Sigma\left(\frac{1+0.05}{1+0.10}\right)^{20}$$

+ $841 = $6000(0.2394) - $4000(0.1486).

§ Derived by the equation for persent value of net savings; i.e., $11,918 = $19,077 - $8000 + $841.

Annual Value of Net Savings

Measured in annual-value dollars, the net benefits (savings) method finds the difference between the additional annual costs associated with a solar energy system and the annual savings expected to result from it. This can be done by applying the appropriate discount formula to the net present value of savings. The resulting formula is:

$$ANS = c \times PNS$$

Where: ANS = net annual savings;

PNS = present value of net dollar savings;

c = the uniform capital recovery factor, $i/\left[1-(1+i)^{-n}\right]$.

Converted to an annual-value basis (c = 0.1175), the present-value savings of $11,918 from the preceding sample problem, equals $1400. This means that a savings of $1400 per year for 20 years (in constant dollars) is equivalent in value to a savings of $11,918 realized now.

Advantages and Disadvantages of Net Benefits Methods

The net benefits (savings) method has essentially the same advantages and disadvantages as the life-cycle cost method. In fact, the two methods are generally interchangeable.

Benefit/Cost Ratio Methods

Because the benefits of investing in solar energy are in terms of cost savings, a version of the benefit/cost ratio (B/C) method known as the savings-to-investment ratio (SIR) method is often used to evaluate solar energy investment. Like the life-cycle cost and net benefits methods, this method is based on discounted cash flows. The SIR method, however, expresses savings and investment costs as a ratio rather than as a dollar amount.

Savings-To-Investment Ratio

The formula for computing SIR for an investment in solar energy based on costs and savings expressed in present-value terms (alternatively, annual-value cost may be used) is:

$$SIR = \left[- \sum_{k=1}^{H} \sum_{j=1}^{n} (P_k \Delta Q_k b^j) - \sum_{j=1}^{n} a^j (\Delta M_j + \Delta R_j) \right] / \left[\Delta I - \Delta V_n a^n \right]$$

Where: SIR = net discounted savings attributable to solar energy, as a ratio to solar investment costs;

P_k = the initial price of the kth type of conventional energy for energy types k = 1 to H;

Δ = change attributable to solar energy;

Q_k = the quantity required of the kth type of conventional energy (equipment efficiencies should be taken into account in calculating Q_k);

b^j = a formula for finding the present value of an amount in the jth year, escalated at a rate e_k, where k denotes the kth type of energy, and discounted at a rate d; i.e., $b^j = \left[(1+e_k)/(1+d)\right]^j$;

a = the single-present-value formula computed for a designated year from j = 1 to n and discount rate d; i.e., $a^j = (1+d)^{-j}$;

M_j = maintenance costs in year j;

R_j = repair and replacement costs in year j;

I = total first costs associated with the energy systems including design, purchase, installation, building modification, and the value of useful building space lost;

V_n = residual or salvage value at year n, the last year in the evaluation.

The placement of certain costs in the numerator rather than in the denominator of the SIR is largely an arbitrary decision. The SIR equation above shows all recurring costs, including replacement costs in the numerator, and investment or first costs less salvage value in the denominator.

An alternative is to add the present value of replacement costs to first costs in the denominator. A rationale for the approach taken here--that of the including replacement costs with other recurring costs in the numerator--is that it avoids possible confusion over what are repair costs and what are renewal costs of the investment. While this distinction is not important in evaluation of single solar energy installations, it may cause inconsistent measures when the SIR is used to evaluate and compare multiple installations, unless a consistent treatment is followed.

The acceptance criteria for an investment using the SIR method are:

(1) that the savings-to-investment ratio be equal to or greater than 1, both for the total investment and for the last increment in investment costs;

(2) that the system be expanded in size as long as the ratio for the last increment in the investment is greater than 1.0, and is equal to or greater than the ratio at the margin for the next best investment opportunity.

If there is no budget constraint, it pays to expand the solar energy system to the point that the ratio for the last increment of the investment equals 1.0. Because the SIR ratio tends to fall as an investment in solar energy is expanded, a larger, more efficiently sized version of a given project may have a lower SIR for the total investment than a smaller, less efficient version of the same project.

Example of the Savings-To-Investment Ratio Method

Table 28.5 illustrates the SIR method of evaluating an investment in solar energy.

TABLE 28.5 Illustration of the SIR Method*

Solar energy savings in base-year dollars (1)	Present value of energy savings,† dollars (2)	Present value of net replacement cost savings,‡ dollars (3)	SIR numerator [(2) + (3)], dollars (4)	SIR denominator (differential investment cost), dollars (5)	SIR ratio (6)
1500	19,077	841	19,918	8000	2.5

* Based on hypothetical cost data presented in Table 28.1 and derived by the equation for savings-to-investment ratio

+ Derived in Table 28.4, col. 4

± Derived in Table 28.4, col. 5

The initial yearly energy savings from the solar energy system of $1500 amounts to $19,077 over the 20 years when expressed in present-value dollars. To this amount is added the net present-value savings in replacement costs realized because of the assumed longer life of the conventional auxiliary system when it is paired with the solar energy system. [If maintenance, repair, and replacement costs had been assumed to be higher with the solar energy system than without it (e.g., $\Delta M_r > 0$), the present-value increase in these costs would have been subtracted from the energy savings in the numerator of the SIR.]

The net replacement cost saved is equal to the present value of of the $6000 of replacement cost that would otherwise be incurred in 15 years (i.e., $1436), less the present value of the salvage value that would have been realized from the replacement at the end of the 20 year time horizon (i.e., $595). Thus the numerator of the SIR is equal to $19,918, the denominator is equal to $8000 and the SIR is 2.5. This indicates on the average a $2.50 return per investment dollar over the life cycle.

Advantages and Disadvantages of the Savings-To-Investment Ratio Method

Like the life-cycle cost method and the net savings method, the savings-to-investment ratio method offers the advantage of providing a comprehensive measure of profitability of an investment over its expected life. It offers an advantage over these other two methods by providing a measure which can be compared with comparable measures for competing independent projects to determine the most profitable group of investments available to the investor. That is, it is a useful method for ranking an investment's profitability relative to other projects. At the same time, it is generally less suitable than the other two methods for determining the optimal size of a project, because the SIR tends to fall as investment size increases. To use the measure for sizing projects, it is necessary to compute and compare the SIR for increments in investment size.

Internal Rate of Return Method

The internal rate of return method calculates the rate of return an investment is expected to yeild. Unlike the other methods, the internal rate of return method does not call for the discounting of cash flows on the basis of a prespecified discount rate. Rather, the method solves for that rate of interest which when used to discount both costs and savings will cause the two to be equal, resulting in a net savings of zero. The rate of return is generally calculated by a trial-and-error process by which various rates of interest are used to discount cash flows until a rate is found for which the net value of the investment is zero.

The internal rate of return method may be described algebraically as follows: given values of other parameters, find the value of i that satisfies the equation:

$$-\left[\sum_{k=1}^{H}\sum_{k=1}^{n}(P_k\Delta Q_k)b^j\right] = \left[(\Delta I - \Delta V_n a^n) + \sum_{j=1}^{n}(\Delta M_j + \Delta R_j)a^j\right]$$

Where: i = the compound rate of interest which when inserted in the expressions b^j and a^j solves the equation; this value of i is the internal rate of return on the investment;

P_k = the initial price of the kth type of conventional energy for energy types $k = 1$ to H;

Δ = change attributable to solar energy;

Q_k = the quantity required of the kth type of conventional energy (equipment efficiencies should be taken into account in calculating Q_k);

b^j = $(1 + e_k)/(1 + d)^j$ = a formula for finding the present value of an amount in the jth year, escalated at a rate e_k, where k denotes the kth type of energy and discounted at a rate d;

I = total first costs associated with the energy system, including design, purchase, installation, building modification, and the value of useful building space lost;

V_n = residual or salvage value at year n, the last year in the evaluation;

a = the single-present-value formula computed for a designated year from $j = 1$ to n and discount rate d; i.e., $a^j = (1 + d)^{-j}$;

M_j = maintenance costs in year j;

R_j = repair and replacement costs in year j.

The economic efficiency criterion for accepting an investment based on the internal rate of return method is that the calculated rate of return be equal to or larger than the investor's minimum attractive rate of return. The method can be used to compare the return on an investment in solar energy with the return on investment alternatives, in order to maximinze the return from a given budget. The selection criterion is to choose individual investments in descending order of their expected rates of return, as long as the rates of return are equal to or exceed the minimum attractive rate of return, until the total budget is exhausted. The criterion for using this method to determine the most economical size of a solar energy system is to increase the size of the system as long as the rate of return on each investment increment is greater than the investor's minimum acceptable rate of return.

Example of the Internal Rate of Return Method

Table 28.6 shows the calculation of the internal rate of return method for the sample hypothetical data that was used to illustrate the other life-cycle costing evaluation methods.

TABLE 28.6 Illustration of the Internal Rate of Return Method*

Trial interest rates (1)	Solar differential investment cost, dollars (2)	Present value of energy savings,† dollars (3)	Present value of net replacement cost savings,‡ dollars (4)	Net present value based on the trial interest rates,§ dollars (5)
20	8000	9773	285	2058
25	8000	7634	165	−201

By interpolation, $i = 0.20 + 0.05[\$2058/(2058 + 201)]$
$i = 0.246$, the internal rate of return on the investment for NPV = 0

* Based on hypothetical cost data presented in Table 28.1 and derived by the equation for internal rate of return.

† Based on base-year savings of \$1500 and derived using the uniform-present-value formula with a factor for fuel escalation, for an interest rate first of 20% and then of 25%.

‡ Derived by applying to the replacement cost and salvage value the appropriate single present-value factors for an interest rate first of 20% and then of 25%; i.e., for i = 0.20, \$285 = \$6000(0.0649) - \$4000 (0.0261; for i = 0.25, \$165 = \$6000 (0.0352) - \$4000(0.0115).

§ \$2058 = \$9773 - (\$8000 - \$285); - \$201 = \$7634 - (\$8000 - \$165).

By trial and error it is found that the investment saves \$2058 when evaluated with a 20 percent interest rate, but loses \$201 when evaluated with a 25 percent interest rate. It therefore may be concluded that the rate of interest which will equate the total of savings and costs to zero lies between 20 and 25 percent. As shown in the table, interpolation can be used to determine that the internal rate of return is 24.6 percent. If this rate is greater than the investor's minimum attractive rate of return, the investment is economically attractive.

Advantages and Disadvantages of the Internal Rate of Return Method

The internal rate of return method shares with the life-cycle cost, net benefits, and benefit/cost ratio methods the advantage of providing a comprehensive evaluation of an investment in solar energy. A unique characteristic of this method, which might sometimes be an advantage, is the lack of necessity to specify the discount rate. However, it is necessary to have an estimate of the minimally attractive rate of return against which the calculated internal rate of return can be compared to decide the desirability of the investment.

The method has several possible disadvantages. Under certain circumstances there may be either no determinable solution or multiple solutions. However, this problem will probably be rare in evaluating solar energy systems. As in the case of the savings-to-investment ratio method, a problem may arise in using the internal rate of return method to determine the economically efficient size of a solar energy system. As an investment is expanded, the rate of return on the overall investment may fall, but the rate of return of the additional investment may nevertheless be above the minimum attractive rate of return. As in the other case, however, this problem can be overcome by using the internal rate of return method to analyze incremental changes in the investment rather than the total investment. Like the savings-to-investment ratio method, this method has the advantage of indicating the relative efficiencies of alternative investments. It therefore may be useful in comparing solar energy with other investment options.

APPENDIX

Tables of Interest Factors for Discrete Compounding Periods

8% Interest

10% Interest

12% Interest

15% Interest

20% Interest

25% Interest

A Worksheet Example for Net Benefits Life-cycle Costing

Step 1 A

Step 2 A

Step 2 B

LCA-1

LCA-2

LCA-3

Figure 4 (Repayment on Loan)

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TABLE 2 8% Interest Factors for Discrete Compounding Periods

	Single payment		Uniform series					
	Compound amount factor	Present worth factor	Capital, recovery factor	Present worth factor	Sinking fund factor	Compound amount factor	Gradient factor	
N	(*F/P*, 8, *N*)	(*P/F*, 8, *N*)	(*A/P*, 8, *N*)	(*P/A*, 8, *N*)	(*A/F*, 8, *N*)	(*F/A*, 8, *N*)	(*A/G*, 8, *N*)	*N*
1	1.0800	.92593	1.0800	.9259	1.0000	1.0000	.0000	1
2	1.1664	.85734	.56077	1.7832	.48077	2.0799	.4807	2
3	1.2597	.79383	.38803	2.5770	.30804	3.2463	.9487	3
4	1.3604	.73503	.30192	3.3121	.22192	4.5060	1.4038	4
5	1.4693	.68059	.25046	3.9926	.17046	5.8665	1.8463	5
6	1.5868	.63017	.21632	4.6228	.13632	7.3358	2.2762	6
7	1.7138	.58349	.19207	5.2063	.11207	8.9227	2.6935	7
8	1.8509	.54027	.17402	5.7466	.09402	10.636	3.0984	8
9	1.9989	.50025	.16008	6.2468	.08008	12.487	3.4909	9
10	2.1589	.46320	.14903	6.7100	.06903	14.486	3.8712	10
11	2.3316	.42889	.14008	7.1389	.06008	16.645	4.2394	11
12	2.5181	.39712	.13270	7.5360	.05270	18.976	4.5956	12
13	2.7196	.36770	.12642	7.9037	.04652	21.495	4.9401	13
14	2.9371	.34046	.12130	8.2442	.04130	24.214	5.2729	14
15	3.1721	.31524	.11683	8.5594	.03683	27.151	5.5943	15
16	3.4259	.29189	.11298	8.8513	.03298	30.323	5.9045	16
17	3.6999	.27027	.10963	9.1216	.02963	33.749	6.2036	17
18	3.9959	.25025	.10670	9.3718	.02670	37.449	6.4919	18
19	4.3156	.23171	.10413	9.6035	.02413	41.445	6.7696	19
20	4.6609	.21455	.10185	9.8181	.02185	45.761	7.0368	20
21	5.0337	.19866	.09983	10.016	.01983	50.422	7.2939	21
22	5.4364	.18394	.09803	10.200	.01803	55.455	7.5411	22
23	5.8713	.17032	.09642	10.371	.01642	60.892	7.7785	23
24	6.3410	.15770	.09498	10.528	.01498	66.763	8.0065	24
25	6.8483	.14602	.09368	10.674	.01368	73.104	8.2253	25
26	7.3962	.13520	.09251	10.809	.01251	79.953	8.4351	26
27	7.9879	.12519	.09145	10.935	.01145	87.349	8.6362	27
28	8.6269	.11592	.09049	11.051	.01049	95.337	8.8288	28
29	9.3171	.10733	.08962	11.158	.00962	103.96	9.0132	29
30	10.062	.09938	.08883	11.257	.00883	113.28	9.1896	30
31	10.867	.09202	.08811	11.349	.00811	123.34	9.3583	31
32	11.736	.08520	.08745	11.434	.00745	134.21	9.5196	32
33	12.675	.07889	.08685	11.513	.00685	145.94	9.6736	33
34	13.689	.07305	.08630	11.586	.00630	158.62	9.8207	34
35	14.785	.06764	.08580	11.654	.00580	172.31	9.9610	35
40	21.724	.04603	.08386	11.924	.00386	259.05	10.569	40
45	31.919	.03133	.08259	12.108	.00259	386.49	11.044	45
50	46.900	.02132	.08174	12.233	.00174	573.75	11.410	50
55	68.911	.01451	.08118	12.318	.00118	848.89	11.690	55
60	101.25	.00988	.08080	12.376	.00080	1253.1	11.901	60
65	148.77	.00672	.08054	12.416	.00054	1847.1	12.060	65
70	218.59	.00457	.08037	12.442	.00037	2719.9	12.178	70
75	321.19	.00311	.08025	12.461	.00025	4002.3	12.265	75
80	471.93	.00212	.08017	12.473	.00017	5886.6	12.330	80
85	693.42	00144	.08012	12.481	.00012	8655.2	12.377	85
90	1018.8	.00098	08008	12.487	.00008	12,723.9	12.411	90
95	1497.0	.00067	08005	12.491	.00005	18,701.5	12.436	95
100	2199.6	.00045	.08004	12.494	.00004	27,484.5	12.454	100

TABLE .3 10% Interest Factors for Discrete Compounding Periods

	Single payment		Uniform series					
	Compound amount factor	Present worth factor	Capital recovery factor	Present worth factor	Sinking fund factor	Compound amount factor	Gradient factor	
N	(F/P, 10, N)	(P/F, 10, N)	(A/P, 10, N)	(P/A, 10, N)	(A/F, 10, N)	(F/A, 10, N)	(A/G, 10, N)	N
1	1.1000	.90909	1.1000	.9091	1.0000	1.000	.0000	1
2	1.2100	.82645	.57619	1.7355	.47619	2.0999	.4761	2
3	1.3310	.75132	.40212	2.4868	.30212	3.3099	.9365	3
4	1.4641	.68302	.31547	3.1698	.21547	4.6409	1.3810	4
5	1.6105	.62092	.26380	3.7907	.16380	6.1050	1.8100	5
6	1.7715	.56448	.22961	4.3552	.12961	7.7155	2.2234	6
7	1.9487	.51316	.20541	4.8683	.10541	9.4870	2.6215	7
8	2.1435	.46651	.18745	5.3349	.08745	11.435	3.0043	8
9	2.3579	.42410	.17364	5.7589	.07364	13.579	3.3722	9
10	2.5937	.38555	.16275	6.1445	.06275	15.937	3.7253	10
11	2.8530	.35050	.15396	6.4950	.05396	18.530	4.0639	11
12	3.1384	.31863	.14676	6.8136	.04676	21.383	4.3883	12
13	3.4522	.28967	.14078	7.1033	.04078	24.522	4.6987	13
14	3.7974	.26333	.13575	7.3666	.03575	27.974	4.9954	14
15	4.1771	.23940	.13147	7.6060	.03147	31.771	5.2788	15
16	4.5949	.21763	.12782	7.8236	.02782	35.949	5.5492	16
17	5.0544	.19785	.12466	8.0215	.02466	40.543	5.8070	17
18	5.5598	.17986	.12193	8.2013	.02193	45.598	6.0524	18
19	6.1158	.16351	.11955	8.3649	.01955	51.158	6.2860	19
20	6.7273	.14865	.11746	8.5135	.01746	57.273	6.5080	20
21	7.4001	.13513	.11562	8.6486	.01562	64.001	6.7188	21
22	8.1401	.12285	.11401	8.7715	.01401	71.401	6.9188	22
23	8.9541	.11168	.11257	8.8832	.01257	79.541	7.1084	23
24	9.8495	.10153	.11130	8.9847	.01130	88.495	7.2879	24
25	10.834	.09230	.11017	9.0770	.01017	98.344	7.4579	25
26	11.917	.08391	.10916	9.1609	.00916	109.17	7.6185	26
27	13.109	.07628	.10826	9.2372	.00826	121.09	7.7703	27
28	14.420	.06935	.10745	9.3065	.00745	134.20	7.9136	28
29	15.862	.06304	.10673	9.3696	.00673	148.62	8.0488	29
30	17.448	.05731	.10608	9.4269	.00608	164.48	8.1761	30
31	19.193	.05210	.10550	9.4790	.00550	181.93	8.2961	31
32	21.113	.04736	.10497	9.5263	.00497	201.13	8.4090	32
33	23.224	.04306	.10450	9.5694	.00450	222.24	8.5151	33
34	25.546	.03914	.10407	9.6085	.00407	245.46	8.6149	34
35	28.101	.03559	.10369	9.6441	.00369	271.01	8.7085	35
40	45.257	.02210	.10226	9.7790	.00226	442.57	9.0962	40
45	72.887	.01372	.10139	9.8628	.00139	718.87	9.3740	45
50	117.38	.00852	.10086	9.9148	.00086	1163.8	9.5704	50
55	189.04	.00529	.10053	9.9471	.00053	1880.4	9.7075	55
60	304.46	.00328	.10033	9.9671	.00033	3034.6	9.8022	60
65	490.34	.00204	.10020	9.9796	.00020	4893.4	9.8671	65
70	789.69	.00127	.10013	9.9873	.00013	7886.9	9.9112	70
75	1271.8	.00079	.10008	9.9921	.00008	12,709.0	9.9409	75
80	2048.2	.00049	.10005	9.9951	.00005	20,474.0	9.9609	80
85	3298.7	.00030	.10003	9.9969	.00003	32,979.7	9.9742	85
90	5312.5	.00019	.10002	9.9981	.00002	53,120.2	9.9830	90
95	8555.9	.00012	.10001	9.9988	.00001	85,556.8	9.9889	95
100	13,780.6	.00007	.10001	9.9992	.00001	137,796.1	9.9927	100

Table 4 12% Interest Factors for Discrete Compounding Periods

	Single payment		Uniform series					
	Compound amount factor	Present worth factor	Capital recovery factor	Present worth factor	Sinking fund factor	Compound amount factor	Gradient factor	
N	(*F/P*, 12, *N*)	(*P/F*, 12, *N*)	(*A/P*, 12, *N*)	(*P/A*, 12, *N*)	(*A/F*, 12, *N*)	(*F/A*, 12, *N*)	(*A/G*, 12, *N*)	*N*
1	1.1200	.89286	1.1200	.8929	1.0000	1.0000	.0000	1
2	1.2544	.79719	.59170	1.6900	.47170	2.1200	.4717	2
3	1.4049	.71178	.41635	2.4018	.29635	3.3743	.9246	3
4	1.5735	.63552	.32924	3.0373	.20924	4.7793	1.3588	4
5	1.7623	.56743	.27741	3.6047	.15741	6.3528	1.7745	5
6	1.9738	.50663	.24323	4.1114	.12323	8.115	2.1720	6
7	2.2106	.45235	.21912	4.5637	.09912	10.088	2.5514	7
8	2.4759	.40388	.20130	4.9676	.08130	12.299	2.9131	8
9	2.7730	.36061	.18768	5.3282	.06768	14.775	3.2573	9
10	3.1058	.32197	.17698	5.6502	.05698	17.548	3.5846	10
11	3.4785	.28748	.16842	5.9376	.04842	20.654	3.8952	11
12	3.8959	.25668	.16144	6.1943	.04144	24.132	4.1896	12
13	4.3634	.22918	.15568	6.4235	.03568	28.028	4.4682	13
14	4.8870	.20462	.15087	6.6281	.03087	32.392	4.7316	14
15	5.4735	.18270	.14682	6.8108	.02682	37.279	4.9802	15
16	6.1303	.16312	.14339	6.9739	.02339	42.752	5.2146	16
17	6.8659	.14565	.14046	7.1196	.02046	48.883	5.4352	17
18	7.6899	.13004	.13794	7.2496	.01794	55.749	5.6427	18
19	8.6126	.11611	.13576	7.3657	.01576	63.439	5.8375	19
20	9.6462	.10367	.13388	7.4694	.01388	72.051	6.0201	20
21	10.803	.09256	.13224	7.5620	.01224	81.698	6.1913	21
22	12.100	.08264	.13081	7.6446	.01081	92.501	6.3513	22
23	13.552	.07379	.12956	7.7184	.00956	104.60	6.5009	23
24	15.178	.06588	.12846	7.7843	.00846	118.15	6.6406	24
25	16.999	.05882	.12750	7.8431	.00750	133.33	6.7708	25
26	19.039	.05252	.12665	7.8956	.00665	150.33	6.8920	26
27	21.324	.04689	.12590	7.9425	.00590	169.37	7.0049	27
28	23.883	.04187	.12524	7.9844	.00524	190.69	7.1097	28
29	26.749	.03738	.12466	8.0218	.00466	214.58	7.2071	29
30	29.959	.03338	.12414	8.0551	.00414	241.32	7.2974	30
31	33.554	.02980	.12369	8.0849	.00369	271.28	7.3810	31
32	37.581	.02661	.12328	8.1116	.00328	304.84	7.4585	32
33	42.090	.02376	.12292	8.1353	.00292	342.42	7.5302	33
34	47.141	.02121	.12260	8.1565	.00260	384.51	7.5964	34
35	52.798	.01894	.12232	8.1755	.00232	431.65	7.6576	35
40	93.049	.01075	.12130	8.2437	.00130	767.07	7.8987	40
45	163.98	.00610	.12074	8.2825	.00074	1358.2	8.0572	45
50	288.99	.00346	.12042	8.3045	.00042	2399.9	8.1597	50

TABLE .5 15% Interest Factors for Discrete Compounding Periods

	Single payment		Uniform series					
	Compound amount factor	Present worth factor	Capital recovery factor	Present worth factor	Sinking fund factor	Compound amount factor	Gradient factor	
N	(*F*/*P*, 15, *N*)	(*P*/*F*, 15, *N*)	(*A*/*P*, 15, *N*)	(*P*/*A*, 15, *N*)	(*A*/*F*, 15, *N*)	(*F*/*A*, 15, *N*)	(*A*/*G*, 15 *N*)	*N*
1	1.1500	.86957	1.1500	.8696	1.0000	1.000	.0000	1
2	1.3225	.75614	.61512	1.6257	.46512	2.1499	.4651	2
3	1.5208	.65752	.43798	2.2832	.28798	3.4724	.9071	3
4	1.7490	.57175	.35027	2.8549	.20027	4.9933	1.3262	4
5	2.0113	.49718	.29832	3.3521	.14832	6.7423	1.7227	5
6	2.3130	.43233	.26424	3.7844	.11424	8.7536	2.0971	6
7	2.6600	.37594	.24036	4.1604	.09036	11.066	2.4498	7
8	3.0590	.32690	.22285	4.4873	.07285	13.726	2.7813	8
9	3.5178	.28426	.20957	4.7715	.05957	16.785	3.0922	9
10	4.0455	.24719	.19925	5.0187	.04925	20.303	3.3831	10
11	4.6523	.21494	.19107	5.2337	.04107	24.349	3.6549	11
12	5.3502	.18691	.18448	5.4206	.03448	29.001	3.9081	12
13	6.1527	.16253	.17911	5.5831	.02911	34.351	4.1437	13
14	7.0756	.14133	.17469	5.7244	.02469	40.504	4.3623	14
15	8.1369	.12290	.17102	5.8473	.02102	47.579	4.5649	15
16	9.3575	.10687	.16795	5.9542	.01795	55.716	4.7522	16
17	10.761	.09293	.16537	6.0471	.01537	65.074	4.9250	17
18	12.375	.08081	.16319	6.1279	.01319	75.835	5.0842	18
19	14.231	.07027	.16134	6.1982	.01134	88.210	5.2307	19
20	16.366	.06110	.15976	6.2593	.00976	102.44	5.3651	20
21	18.821	.05313	.15842	6.3124	.00842	118.80	5.4883	21
22	21.644	.04620	.15727	6.3586	.00727	137.62	5.6010	22
23	24.891	.04018	.15628	6.3988	.00628	159.27	5.7039	23
24	28.624	.03493	.15543	6.4337	.00543	184.16	5.7978	24
25	32.918	.03038	.15470	6.4641	.00470	212.78	5.8834	25
26	37.856	.02642	.15407	6.4905	.00407	245.70	5.9612	26
27	43.534	.02297	.15353	6.5135	.00353	283.56	6.0318	27
28	50.064	.01997	.15306	6.5335	.00306	327.09	6.0959	28
29	57.574	.01737	.15265	6.5508	.00265	377.16	6.1540	29
30	66.210	.01510	.15230	6.5659	.00230	434.73	6.2066	30
31	76.141	.01313	.15200	6.5791	.00200	500.94	6.2541	31
32	87.563	.01142	.15173	6.5905	.00173	577.08	6.2970	32
33	100.69	.00993	.15150	6.6004	.00150	664.65	6.3356	33
34	115.80	.00864	.15131	6.6091	.00131	765.34	6.3705	34
35	133.17	.00751	.15113	6.6166	.00113	881.14	6.4018	35
40	267.85	.00373	.15056	6.6417	.00056	1779.0	6.5167	40
45	538.75	.00186	.15028	6.6543	.00028	3585.0	6.5829	45
50	1083.6	.00092	.15014	6.6605	.00014	7217.4	6.8204	50

Table 6 20% Interest Factors for Discrete Compounding Periods

	Single payment		Uniform series					
	Compound amount factor	Present worth factor	Capital recovery factor	Present worth factor	Sinking fund factor	Compound amount factor	Gradient factor	
N	(*F*/*P*, 20, *N*)	(*P*/*F*, 20, *N*)	(*A*/*P*, 20, *N*)	(*P*/*A*, 20, *N*)	(*A*/*F*, 20, *N*)	(*F*/*A*, 20, *N*)	(*A*/*G*, 20, *N*)	*N*
1	1.2000	.83333	1.2000	.8333	1.000	1.0000	.0000	1
2	1.4400	.69445	.65455	1.5277	.45455	2.1999	.4545	2
3	1.7280	.57870	.47473	2.1064	.27473	3.6399	.8791	3
4	2.0736	.48225	.38629	2.5887	.18629	5.3679	1.2742	4
5	2.4883	.40188	.33438	2.9906	.13438	7.4415	1.6405	5
6	2.9859	.33490	.30071	3.3255	.10071	9.9298	1.9788	6
7	3.5831	.27908	.27742	3.6045	.07742	12.915	2.2901	7
8	4.2998	.23257	.26061	3.8371	.06061	16.498	2.5756	8
9	5.1597	.19381	.24808	4.0309	.04808	20.798	2.8364	9
10	6.1917	.16151	.23852	4.1924	.03852	25.958	3.0739	10
11	7.4300	.13459	.23110	4.3270	.03110	32.150	3.2892	11
12	8.9160	.11216	.22527	4.4392	.02527	39.580	3.4840	12
13	10.699	.09346	.22062	4.5326	.02062	48.496	3.6596	13
14	12.839	.07789	.21689	4.6105	.01689	59.195	3.8174	14
15	15.406	.06491	.21388	4.6754	.01388	72.034	3.9588	15
16	18.488	.05409	.21144	4.7295	.01144	87.441	4.0851	16
17	22.185	.04507	.20944	4.7746	.00944	105.92	4.1975	17
18	26.623	.03756	.20781	4.8121	.00781	128.11	4.2975	18
19	31.947	.03130	.20646	4.8435	.00646	154.73	4.3860	19
20	38.337	.02608	.20536	4.8695	.00536	186.68	4.4643	20
21	46.004	.02174	.20444	4.8913	.00444	225.02	4.5333	21
22	55.205	.01811	.20369	4.0094	.00369	271.02	4.5941	22
23	66.246	.01510	.20307	4.9245	.00307	326.23	4.6474	23
24	79.495	.01258	.20255	4.9371	.00255	392.47	4.6942	24
25	95.394	.01048	.20212	4.9475	.00212	471.97	4.7351	25
26	114.47	.00874	.20176	4.9563	.00176	567.36	4.7708	26
27	137.36	.00728	.20147	4.9636	.00147	681.84	4.8020	27
28	164.84	.00607	.20122	4.9696	.00122	819.21	4.8291	28
29	197.81	.00506	.20102	4.9747	.00102	984.05	4.8526	29
30	237.37	.00421	.20085	4.9789	.00085	1181.8	4.8730	30
31	284.84	.00351	.20070	4.9824	.00070	1419.2	4.8907	31
32	341.81	.00293	.20059	4.9853	.00059	1704.0	4.9061	32
33	410.17	.00244	.20049	4.9878	.00049	2045.8	4.9193	33
34	492.21	.00203	.20041	4.9898	.00041	2456.0	4.9307	34
35	590.65	.00169	.20034	4.9915	.00034	2948.2	4.9406	35
40	1469.7	.00068	.20014	4.9966	.00014	7343.6	4.9727	40
45	3657.1	.00027	.20005	4.9986	.00005	18,281.3	4.9876	45
50	9100.1	.00011	.20002	4.9994	.00002	45,497.2	4.9945	50

TABLE 7 25% Interest Factors for Discrete Compounding Periods

	Single payment		Uniform series					
	Compound amount factor	Present worth factor	Capital recovery factor	Present worth factor	Sinking fund factor	Compound amount factor	Gradient factor	
N	(*F/P*, 25, *N*)	(*P/F*, 25, *N*)	(*A/P*, 25, *N*)	(*P/A*, 25, *N*)	(*A/F*, 25, *N*)	(*F/A*, 25, *N*)	(*A/G*, 25, *N*)	*N*
1	1.2500	.80000	1.2500	.8000	1.0000	1.0000	.00000	1
2	1.5625	.64000	.69444	1.4400	.44444	2.2500	.44444	2
3	1.9531	.51200	.51230	1.9520	.26230	3.8125	.85246	3
4	2.4414	.40960	.42344	2.3616	.17344	5.7656	1.2249	4
5	3.0518	.32768	.37185	2.6893	.12185	8.2070	1.5631	5
6	3.8147	.26214	.33882	2.9514	.08882	11.259	1.8683	6
7	4.7684	.20972	.31634	3.1661	.06634	15.073	2.1424	7
8	5.9605	.16777	.30040	3.3289	.05040	19.842	2.3872	8
9	7.4506	.13422	.28876	3.4631	.03876	25.802	2.6048	9
10	9.3132	.10737	.28007	3.5705	.03007	33.253	2.7971	10
11	11.642	.08590	.27349	3.6564	.02349	42.566	2.9663	11
12	14.552	.06872	.26845	3.7251	.01845	54.208	3.1145	12
13	18.190	.05498	.26454	3.7801	.01454	68.760	3.2437	13
14	22.737	.04398	.26150	3.8241	.01150	86.949	3.3559	14
15	28.422	.03518	.25912	3.8593	.00912	109.687	3.4530	15
16	35.527	.02815	.25724	3.8874	.00724	138.109	3.5366	16
17	44.409	.02252	.25576	3.9099	.00576	173.636	3.6084	17
18	55.511	.01801	.25459	3.9279	.00459	218.045	3.6698	18
19	69.389	.01441	.25366	3.9424	.00366	273.556	3.7222	19
20	86.736	.01153	.25292	3.9539	.00292	342.945	3.7667	20
21	108.420	.00922	.25233	3.9631	.00233	429.681	3.8045	21
22	135.525	.00738	.25186	3.9705	.00186	538.101	3.8365	22
23	169.407	.00590	.25148	3.9764	.00148	673.626	3.8634	23
24	211.758	.00472	.25119	3.9811	.00119	843.033	3.8861	24
25	264.698	.00378	.25095	3.9849	.00095	1054.791	3.9052	25
26	330.872	.00302	.25076	3.9879	.00076	1319.489	3.9212	26
27	413.590	.00242	.25061	3.9903	.00061	1650.361	3.9346	27
28	516.988	.00193	.25048	3.9923	.00048	2063.952	3.9457	28
29	646.235	.00155	.25039	3.9938	.00039	2580.939	3.9551	39
30	807.794	.00124	.25031	3.9950	.00031	3227.174	3.9628	30
31	1009.742	.00099	.25025	3.9960	.00025	4034.968	3.9693	31
32	1262.177	.00079	.25020	3.9968	.00020	5044.710	3.9746	32
33	1577.722	.00063	.25016	3.9975	.00016	6306.887	3.9791	33
34	1972.152	.00051	.25013	3.9980	.00012	7884.609	3.9828	34
35	2465.190	.00041	.25010	3.9984	.00010	9856.761	3.9858	35

STEP 1A. COLLECTOR SIZING — SHORT FORM METHOD WORKSHEET

Line 1. Design Heat Loss of Structure (Btuh):
(from standard heat loss calculation) .... 55,440 Btuh

Line 2. Winter Design Temperature Difference (°F):
(Indoor Design Temp. 70) – (Outdoor Design Temp. -10) = 80 °F

Line 3. Space Heat Load (Btu per degree-day):
(Line 1 55,440) x 24 x .75
(Line 2 80)
= .... 12,474 Btu/D-day

Line 4. Desired Annual Solar Percentage of Total Load:
25%, 50% or 75% .... 50 %

Line 5. Approximate Total Collector Area (sq. ft.):
(Line 3 12,474)
LC Factor 46 (from LC Factor Table for ______)
= .... 271 sq. ft.

Line 6. Effective Absorber Area Per Collector (from
Engineering Handbook Solar Collector sheet) .... 15.4 sq. ft.

Line 7. Estimated Number of Collectors:
(Line 5 271)
(Line 6 15.4)
= .... 17.6 or 18 collectors

Line 8. Effective Area of Collector Array (sq. ft.):
(Line 6 15.4) x (Line 7 18) = ... 277 sq. ft.

LC FACTOR TABLE

CITY, STATE	LATITUDE	SOLAR PERCENTAGE OF TOTAL LOAD		
		25%	50%	75%
Ames, Ia.	42.0	134	46	19
Albuquerque, N.M.	35.0	334	120	60
Atlanta, Ga.	33.4	316	109	46
Boulder, Colo.	40.0	191	74	35
Columbus, Oh.	40.0	131	40	14
Dallas, Tx.	32.5	416	133	58
Davis, Ca.	38.3	394	120	46
Miami, Fl.	25.5	1443	646	382
Norfolk, Va.	36.5	270	90	40
San Diego, Ca.	32.4	459	211	112
Edmonton, At.	53.3	96	35	14
Moncton, N.B.	40.0	84	25	8
Toronto, Ot.	43.4	98	30	10
Vancouver, B.C.	48.6	102	28	8
Winnipeg, Ma.	49.5	94	33	13

COLLECTOR SIZING — LONG FORM METHOD

STEP 2A. HEAT LOAD WORKSHEET

(Instructions for this worksheet on next page.)

Line 1. Design Heat Loss of Structure (Btuh) .... 55,440 Btuh
(from standard heat loss calculation)

Line 2. Winter Design Temperature Difference (°F):
(Indoor Design Temp. 70) - (Outdoor Design Temp. -10) = .. 80 °F

Line 3. Space Heat Load (Btu per degree-day):

$$\frac{(\text{Line 1 } 55.440\text{ }) \times 24 \times .75)}{(\text{Line 2 } 80\text{ })} = \text{.......................... } 12{,}474 \text{ Btu/D-day}$$

Line 4. Hot Water Temperature Difference (°F):
(Setpoint Temperature 140°F) –
(Cold Water Supply Temperature 55°F) = ... 85 °F

Line 5. Hot Water Consumption (gal. per day) .... 80 gal./day

Line 6. Hot Water Load (Btu per day):
(Line 4 85) x (Line 5 80) x 8.33 = ... 56,644 Btu/day

Column A		Column B	Column C	Column D	Column E
DAYS PER MONTH		HEATING DEGREE-DAYS (from Wea. & Rad.Tables for____)	SPACE HEAT LOAD (Btu/mo.): (Line 3) x (Column B) x (Abbreviation Factor*)	WATER HEAT LOAD (Btu/mo.): (Line 6) x (Column A) x (Abbreviation Factor*)	TOTAL HEAT LOAD (Btu/mo.): (Column C Abbreviation) + (Column D Abbreviation)
Jan.	31	1429	17.83 x 10^6	1.76 x 10^6	19.59 x 10^6
Feb.	28	1151	14.36 " "	1.59 " "	15.95 " "
Mar.	31	970	12.10 " "	1.76 " "	13.86 " "
Apr.	30	468	5.84 " "	1.70 " "	7.54 " "
May	31	191	2.38 " "	1.76 " "	4.14 " "
June	30	32	0.40 " "	1.70 " "	2.10 " "
July	31	0	0.00	1.76 " "	1.76 " "
Aug.	31	15	0.19 " "	1.76 " "	1.95 " "
Sept.	30	105	1.31 " "	1.70 " "	3.01 " "
Oct.	31	370	4.62 " "	1.76 " "	6.38 " "
Nov.	30	834	10.40 " "	1.70 " "	12.10 " "
Dec.	31	1259	15.70 " "	1.76 " "	17.46 " "
TOTAL	365	6824	85.13 " "	20.71 " "	105.84 " "

**The abbreviation factor abbreviates and rounds a large number by moving decimal six digits to the left; rounding to two decimal numbers; and multiplying by 10^6. (See Step 2A Worksheet Instructions for further explanation.)*

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COLLECTOR SIZING — LONG FORM METHOD

STEP 2B. SOLAR LOAD PERCENTAGE OF TOTAL LOAD WORKSHEET

(Instructions for this worksheet on next page.)

Line 7. Estimated Effective Absorber Area of Collector Array (from line 8 of Step 1A Worksheet or SA/L Short Form Worksheet .... 277 sq. ft.

Line 8. Collector Performance Curve Slope (from Engineering Handbook data) .... .60

Line 9. Collector Peformance Curve Intercept (from Engineering Handbook data) .... .78

Line 10. Collector to Storage Heat Exchanger Factor (.95 is factor for Lennox systems)........ .95

Line 11. Collector Orientation Factor (.95 is factor for Lennox systems)........ .95

Line 12. Preliminary "X" Factor of F-Chart:
(Line 7 277) x (Line 8 .60) x (Line 10 .95) = .. 157.89

Line 13. Preliminary "Y" Factor of F-Chart:
(Line 7 277) x (Line 9 .78) x (Line 10 .95) x
(Line 11 .95) = ... 194.99

Col. F	Col. G	Col. H	Col. I	Col. J	Col. K	Col. L	Col. M	Col. N
DAYS PER MONTH	HOURS PER MONTH	AVERAGE AMBIENT AIR TEMP. (°F): (from Wea. & Rad. Tables)	TEMP. FACTOR: 212-(Col. H)	"X" COORDINATE: (Line 12) x (Col. G) x (Col. I) x (Abbreviation factor*) (Col. E, Step 2A Worksheet Abbreviation)	RADIATION ON TILTED SURFACE (from Wea. & Rad. Tables) Tilt 50° Azm. 0	"Y" COORDINATE: (Line 13) x (Col. F) x (Col. K) x (Abbreviation Factor*) (Col. E, Step 2A Worksheet Abbreviation)	SOLAR PERCENTAGE (from F-Chart)	SOLAR LOAD (Btu/mo.): (Col. E, Step 2A Worksheet Abbreviation) x (Col. M)
J-31	744	19	193	1.16	1283	.40	.31	6.07×10^6
F-28	696	25	187	1.29	1509	.52	.39	6.22 " "
M-31	744	32	180	1.53	1506	.66	.49	6.79 " "
A-30	720	48	164	2.47	1469	1.14	.73	5.50 " "
M-31	744	59	153	4.34	1501	2.19	1.00	4.14 " "
J-30	720	68	144	7.80	1576	4.39	1.00	2.10 " "
J-31	744	73	139	9.28	1609	5.52	1.00	1.76 " "
A-31	744	72	140	8.43	1572	4.87	1.00	1.95 " "
S-30	720	63	149	5.44	154[illegible]	2.99	1.00	3.01 " "
O-31	744	52	160	2.94	1495	1.41	.85	5.42 " "
N-30	720	36	176	1.65	1290	.62	.48	5.81 " "
D-31	744	25	187	1.26	1095	.38	.29	5.06 " "
							YEARLY TOTAL	53.83 " "

Line 14. Yearly Solar Load Percentage:
(Col. N. Abbreviation TOTAL 53.83×10^6)
(Col. E, Step 2A Worksheet Abbreviation TOTAL 105.84×10^6) = ... 50.8 %

The Abbreviation Factor abbreviates and rounds a large number by: moving decimal six digits to the left; rounding to two decimal numbers; and multiplying by 10^6. (See Step 2A Worksheet Instruction for further explanation.)

LIFE-CYCLE COST ANALYSIS
LCA-1 WORKSHEET — BASIC DATA

BUILDING DATA

Line 1. Building Annual Heat Load (from Col. C Total of Step 2A Worksheet in EQUIPMENT SELECTION Section) .... 85 mBtu

Line 2. Hot Water Load (from Col. D Total of Step 2A Worksheet in EQUIPMENT SELECTION Section) .... 21 mBtu

Line 3. Total Annual Heating Load (Line 1 85) + (Line 2 21) = ... 106 mBtu

SOLAR SYSTEM DATA

Line 4. Collector Area (from Line 7 of Step 2B Worksheet in EQUIPMENT SELECTION Section) .... 277 sq. ft.

Line 5. Fraction of Annual Heating Load Carried by Solar (from Line 14 of Step 2B Worksheet in EQUIPMENT SELECTION Section) .... 51 %

Line 6. Unit Cost of Solar System Installed .... 22 $/sq. ft.

Line 7. Installed Cost of Solar System: (Line 4 277) x (Line 7 22) = ... 6,094 $

Line 8. Type of Auxiliary Fuels:
8a. Space Electric 8b. Hot Water Electric

Line 9. Efficiencies of Auxiliary Fuels:
9a. Space 1.00 % 8b. Hot Water 1.00 %

Line 10. Auxiliary Fuel Costs (from Figs. 1 & 2):
10a. Space 8.80 $/mBtu 10b. Hot Water 8.80 $/mBtu

FINANCIAL DATA

Line 11. Terms of Loan: Years 20 Interest Rate .09 %

Line 12. Down Payment on Loan: (.20 %) x (Line 7 6,094) = ... 1,219 $

Line 13. Amount of Loan: (Line 7 6,094) — (Line 12 1,219) = ... 4,875 $

Line 14. Annual Mortgage Payment: (Factor from Fig. 4 .11) x (Line 13 4,875) = ... 536 $/year

TAXES AND INSURANCE

Line 15. Property Tax:
15a. Ratio of Taxable Value to Installed Cost .5 %
15b. Property Tax Rate .02 %
15c. Property Tax: (Line 7 6,094) x (Line 15a. .5) x (Line 15b. .02) = ... 61 $/year

Line 16. Income Tax Rate:
16a. Federal Tax Rate .30 %
16b. State Tax Rate .10 %
16c. Effective Income Tax Rate: (Line 16a. .30) + (Line 16b. .10) — [2 x (Line 16a. .30) x (Line 16b. .10)] = ... .34 %

Line 17. Insurance: (Line 7 6,094) x (Insurance Rate .005) = ... 30 $/year

OPERATION AND MAINTENANCE

Line 18. First Year Operating Cost:
18a. Annual Solar Heat Supplied: (Line 5 51) x (Line 3 106) = 54 mBtu
18b. Fraction of Solar for Electricity .05 %
18c. Operating Cost: (Line 18a. 54) x (Line 18b. .05) x (Line 10a. 8.80) = ... 24 $/year

Line 19. First Year Maintenance Cost = ... 100 $/year

NON-SOLAR SYSTEM DATA

Line 20. First Year Fuel Expenses:
20a. Space: (Line 1 85) x (Line 10a. 8.80) = ... 748 $/year
20b. Hot Water: (Line 2 21) x (Line 10b. 8.80) = ... 185 $/year
20c. Total Fuel Expenses: (Line 20a. 748) + (Line 20b. 185) = ... 933 $/year

Line 21. First Year Operating Expenses: (Line 20c. 933) x (.03 %) = ... 28 $/year

Line 22. First Year Fuel and Operating Expenses: (Line 20c. 933) + (Line 21. 28) = ... 961 $/year

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LIFE-CYCLE COST ANALYSIS
LCA-2 WORKSHEET — SOLAR CASH FLOWS

KEY:

Annual Mortgage Rate .09 %
(from Line 11)

Auxiliary Inflation Rate .07 %

General Inflation Rate .06 %

Collector Area 277 sq. ft.
(from Line 4)

Solar Fraction of Total Load 51 %
(from Line 5)

System Cost 6,094 $
(from Line 7)

Down Payment 1,219 $
(from Line 12)

Col. A	Column B	Column C	Column D	Column E	Column F	Column G	Column H	Column I	Column J	Column K	Column L
YEAR	ANNUAL MORTGAGE PAYMENT (from Line 14)	YEARS LEFT ON MORTGAGE	FRACTION OF MORTGAGE AS INTEREST (from Fig. 4)	INTEREST PAID (Col. B x Col. D)	AUXILIARY FUEL COST (See Note 1.)	PROPERTY TAX (See Note 2.)	INSURANCE (See Note 3.)	OPERATING COST (See Note 4.)	MAINTENANCE COST (See Note 5.)	INCOME TAX SAVINGS (Col. E x Line 16c.)	EXPENSE WITH SOLAR (See Note 6.)
1	536	20	.82	440	457	61	30	24	100	150	2277
2	536	19	.81	434	489	65	32	26	106	148	1106
3	536	18	.79	423	523	69	34	28	112	144	1158
4	536	17	.77	413	560	73	36	30	119	140	1214
5	536	16	.75	402	599	77	38	32	126	137	1271
6	536	15	.72	386	641	82	40	34	134	131	1336
7	536	14	.70	375	686	87	42	36	142	128	1401
8	536	13	.67	359	734	92	45	39	151	122	1475
9	536	12	.64	343	785	98	48	42	160	117	1552
10	536	11	.61	327	840	104	51	45	170	111	1635
11	536	10	.58	311	899	110	54	48	180	106	1721
12	536	9	.54	289	962	117	57	51	191	98	1816
13	536	8	.50	268	1030	124	60	55	202	91	1916
14	536	7	.45	241	1102	131	64	59	214	82	2024
15	536	6	.40	214	1179	139	68	63	227	73	2139
16	536	5	.35	188	1262	147	72	67	241	64	2261
17	536	4	.29	155	1350	156	76	72	255	53	2392
18	536	3	.23	123	1445	165	81	77	270	42	2532
19	536	2	.16	86	1546	175	86	82	286	29	2682
20	536	1	.08	43	1654	186	91	88	303	15	2843

Note 1. First year cost:
(Line 3 106) x (1.0 — Line 5 .51) x (Line 10a. 8.80)
Second and future years: (Previous Year Cost) x (1 + Fuel Inflation Rate)

Note 2. First Year Cost: (Line 15c.)
Second and Future Years: (Previous Year Cost) x (1 + General Inflation Rate)

Note 3. First Year Cost: (Line 17)
Second and future years: (Previous Year Cost) x (1 + General Inflation Rate)

Note 4. First Year Cost: (Line 18)
Second and Future Years: (Previous Year Cost) x (1 + Fuel Inflation Rate)

Note 5. First Year Cost: (Line 19)
Second and Future Years: (Previous Year Cost) x (1 + General Inflation Rate)

Note 6. First Year Cost:
(Down Payment) + (Col. B) + (Col. F) + (Col. G) + (Col. H) + (Col. I) + (Col. J) — (Col. K)
Second and Future Years: (Cols B+E+G+H+I+I K)

LIFE-CYCLE COST ANALYSIS
LCA-3 WORKSHEET — ECONOMIC SUMMARY

KEY:

Fuel Inflation Rate .07 %

Col. M	Column N	Column O	Column P	Column Q	Column O	Column P	Column Q	Column O	Column P	Column Q
YEAR	NON-SOLAR SYSTEM	SOLAR SYSTEM								
		COLLECTOR AREA 277 sq. ft.			COLLECTOR AREA ____ sq. ft.			COLLECTOR AREA ____ sq. ft.		
	FUEL PLUS OPERATING EXPENSE (See Note 1.)	EXPENSE WITH SOLAR (From Col. L)	SAVINGS WITH SOLAR (Col. N) — (Col. O)	CUMULATIVE SAVINGS WITH SOLAR (See Note 2.)	EXPENSE WITH SOLAR (From Col. L)	SAVINGS WITH SOLAR (Col. N) — (Col. O)	CUMULATIVE SAVINGS WITH SOLAR (See Note 2.)	EXPENSE WITH SOLAR (From Col. L)	SAVINGS WITH SOLAR (Col. N) — (Col. O)	CUMULATIVE SAVINGS WITH SOLAR (See Note 2.)
1	961	2277	-1336	-1336						
2	1028	1106	-78	-1414						
3	1100	1158	-58	-1472						
4	1177	1214	-37	-1509						
5	1259	1271	-12	-1521						
6	1347	1336	+11	-15 0						
7	1441	1401	+40	-1470						
8	1542	1475	+67	-1403						
9	1650	1552	+98	-1305						
10	1766	1635	+131	-1174						
11	1890	1721	+169	-1005						
12	2022	1816	+206	-799						
13	2164	1916	+248	-551						
14	2315	2024	+291	-260						
15	2477	2139	+338	+78						
16	2650	2261	+389	+467						
17	2836	2392	+444	+911						
18	3035	2532	+503	+1414						
19	3247	2682	+565	+1979						
20	3474	2843	+631	+2610						

Note 1. First Year Cost: (Line 22)
Second and Future Years:
(Previous Year Cost) x (1 + Fuel Inflation Rate)

Note 2. First Year Savings: (Col. P First Year)
Second and Future Years:
(Previous Year) + (Col. P)

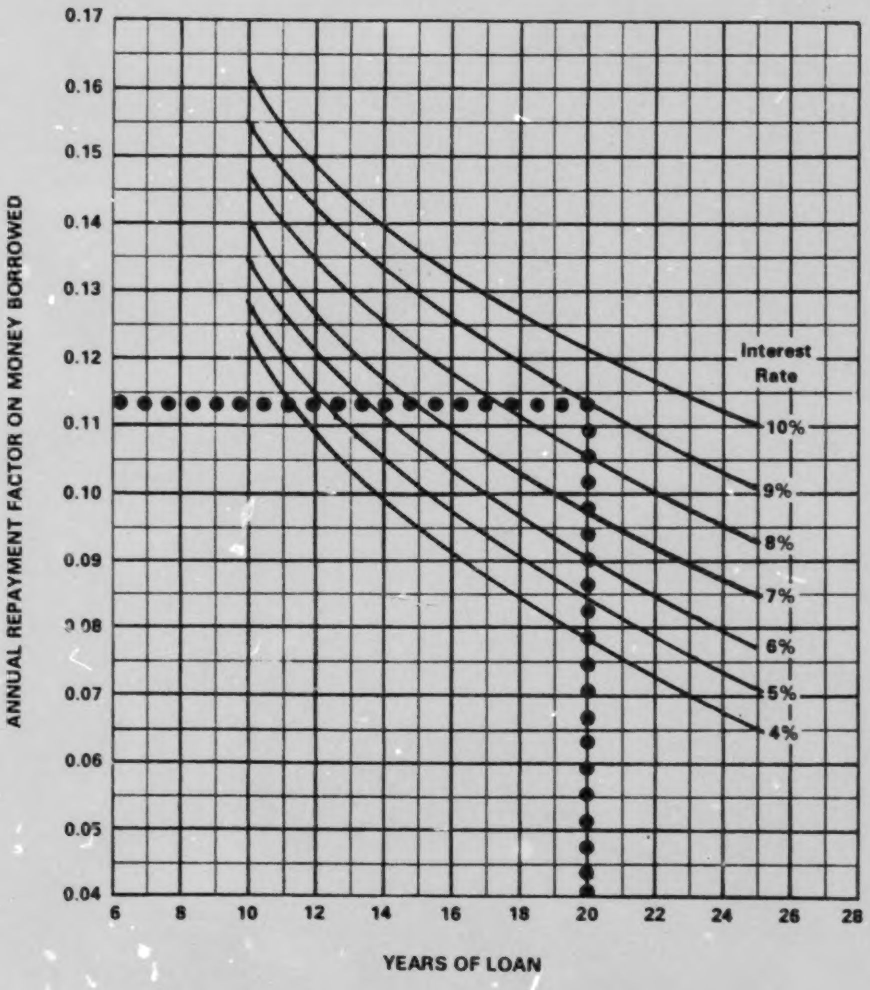

FIGURE 4
REPAYMENT ON LOAN

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CODES, LEGALITIES, CONSUMERISM AND ECONOMICS

UTILITY INTERFACING

STUDENT MATERIAL

CODES, LEGALITIES, CONSUMERISM AND ECONOMICS

UTILITY INTERFACING

INTRODUCTION

Public Utility is a business directly connected with public health and welfare. Such businesses, or public utilities, supply essential commodities or services as water, electricity, gas, telephone, and transportation.

Public utilities must obtain a franchise, or permit, to carry on their businesses, since they occupy the public streets and highways with their mains, pipes, poles, wires, tracks, and the like. Nowadays the franchise is usually granted by the municipality or city which the public utility serves.

The limited space of city streets along with other factors contribute toward making public utilities what are called "natural monopolies". Since monopolies can be dangerous to public welfare, it is necessary that public utilities must either be regulated by some agency of government, or be publicly owned and operated. Good service at reasonable rates can thus be assured.

Over 75 percent of the electrical generating capacity in the United States is the property of private power companies. Although these companies are privately owned, their operations are regulated by state public utility commissions because of the natural monopoly of the utility business. State public utility commissions have generally acted as overseers rather than initiators of policy, although this may be changing in some states. As a practical matter, utility commissions have also lacked the resources and staff to take an aggressive posture.

The Federal Energy Regulatory Commission sets accounting standards and reporting requirements. Recent regulations issued by the Federal Energy Regulatory Commission offer some hope for a more active energy conservation program. The Commission announced recognition of the shift in public concern for the "proper utilization and conservation of our natural resources including fuels and raw materials as well as air, water and land". Although action refelcting these concerns was left for a later date, utilities were asked to submit more detailed rate reports.

Recent congressional proposals would expand federal regulation of utilities. While Congress almost certaily has the power to regulate utilities under the interstate commerce clause, or on the grounds of national security, it seems likely that states will continue to exercise primary responsibility for utility practices.

Utilities and Solar Energy

The role of utilities in solar energy commercialization is controversial and complex. Laws which govern public and private utility companies are incredibly complicated, in addition to varying from one state to another. There is no question, though, that these laws and regulations can either help or hurt the development of solar energy applications.

Public utilities, which currently provide a substantial portion of the energy used to heat buildings, could lose some potential customers if solar-powered heating systems become widespread. Moreover, solar building owners who use electricity as a backup source of energy could cost utilities far more to serve than other residential customers. Since even idle capacity must be paid for, the costs of serving the occasional user may be higher than those for a customer who used the same amount of electricity, but has a steady demand. The owner of a solar system using electrical heating as a backup may in fact impose a demand at times of utility peak demand. Although the battle has hardly begun, one utility has already tried to retaliate by imposing a rate structure that reflects the potentially higher costs of serving solar customers. The Public Service Company of Colorado cited the increasing use of solar heating as one justification for a controversial new rate structure.

On the other hand, some utilities will see an opportunity to profit from participation in the solar energy market. Natural gas companies may soon have to locate alternative sources of energy because proven gas reserves are steadily declining, and at least one gas company, the Southern California Gas Company, has begun experiments with solar-assisted gas heating systems. The company recently requested a rate increase to pay for a demonstration project. A recent survey found over 100 utility projects involving solar energy, most of them in the area of heating and cooling buildings.

From the standpoint of solar energy use, the crucial regulatory function is rate approval. Typically, state regulatory agencies first decide how much a utility will be allowed to earn, and then approve rate schedules designed to produce the approved profit margin. The rate of return is a function of the rate base (those investments on which the utility may make a profit). A utility decision to market or lease solar collectors would have to be approved by the utility commission before these expenses could be added to the rate base.

It should also be noted that the utility profits only if it makes an investment in captial. Therefore, a utility might finance the purchase of solar collectors by homeowners, but it would stand to profit less than from an investment in generating facilities.

Rate structures are also designed to reflect different costs of service. For example, residential consumers have traditionally paid higher rates than large industrial customers because of the lower costs of billing and metering a single large user. Industries willing to accept interruptible service, that is, the possibility service cutoffs during peak periods, also receive a lower rate.

There is one major exception to the scope of utility commission jurisdiction: publicly owned utilities are usually exempt from state jurisdiction because they are already publicly controlled. Some utility critics view locally owned utilities as one alternative to the unresponsiveness of privately owned systems. Whether or not this argument is valid, in the short run municipal utilities are too small to play a major role in national energy issues. They accounted for only 10 percent of total installed capacity in 1972.

The major impediment to solar heating which could be caused by utility companies and state laws is nicely summed up by the following:

> Energy conservation (the use of solar energy) has grave implications for the long-term interests of utilities. It means decreasing demand, and consequently a smaller market. Solar heating and cooling offer an opportunity to satisfy growing demands through actual expansion of the utilities markets. On the other hand, universal use of solar energy for heating and cooling would severely curtail the market for conventional energy on sunny days, and pose severe peak-demand problems on cloudy days. Combined solar and conventional energy for heating and cooling is not only advantageous, but enables the utilities to have their cake and eat it too: They keep their existing market for conventional energy and expand their total market through the control of solar energy.

To some, this may sound ominous. To others who know that utilities understand the high start-up costs and long-term amortization of capital-intensive business (as opposed to the homeowner who may only look at first-cost, and not the life-cycle costs), the idea makes sense. Some further insight into the complexity of issues occurs with consideration of centralized systems as opposed to onsite systems and the integration of the two concepts. ("Onsite" energy systems are defined as small energy units attached to or located near individual buildings, or groups of buildings.)

Centralized Systems

Most electricity generated in the United States originates in large centralized facilities owned and operated by electric utilities. There are a number of explanations for the trend toward centralization:

1. Larger equipment tended to be less expensive per unit of installed capacity.

2. Larger plants tended to be more efficient in their use of fuel and had lower maintenance costs per unit output, since a relatively small number of trained operators could reliably maintain large generating plants.

3. Larger plants could be installed in remote locations, simplifying siting problems and ensuring that pollutants would be released at a distance from populated areas.

4. In recent years, a major advantage of large plants was their ability to use coal instead of oil and gas as a fuel; the delivery of coal to a large plant, using a dedicated rail facility, could significantly reduce the effective cost of coal fuel.

5. Onsite facilities were frequently unable to compete with "promotional" rates charged during the periods when utilities were enjoying declining marginal costs; under those circumstances, all utility customers benefited from increased sales, since average rates declined as utility sales expanded.

6. Many companies were reluctant to invest in onsite equipment because they were unable to finance a large fraction of the equipment with their own equity; they were forced to turn instead to debt financing, which had the effect of increasing company vulnerability during periods of economic hardship; this meant that greater returns were expected of onsite generating equipment than were expected of investments in product-oriented areas.

7. There was a fear that a failure of onsite equipment could have disastrous effects on the operation of a business, and a feeling that the headaches of electricity production should be left to the utilities, whose primary business was energy.

8. Electric utilities have frequently opposed the installation of onsite generating facilities by industry and have often been reluctant to own such equipment themselves.

9. Many onsite facilities have been poorly designed and have received inexpert maintenance, and reports of failures have frightened prospective investors.

10. Onsite generating equipment has tended to be of somewhat archaic design.

11. Federal and industrial research has concentrated almost exclusively on the development of improvements in large centralized equipment rather than in systems optimally designed for onsite generation.

12. Onsite equipment in some installations has created problems of noise and local pollution, and some owners have encountered difficulties in expanding generating facilities.

Onsite Systems

One of the major objectives under study is to determine whether there are or will be circumstances under which the advantages of onsite energy equipment, particularly solar energy equipment, can outweigh the rather impressive set of traditional reasons for avoiding onsite equipment. Widespread use of onsite solar equipment (or indeed of onsite energy equipment of any kind) would reverse a 40-year trend toward centralization of energy sources.

Onsite equipment can offer a number of advantages:

1. Location of equipment "onsite"greatly increases the design opportunities and makes it easier to match energy equipment to specific onsite energy demands.

   In particular, it should make it easier to use the thermal output of solar collectors and the heat rejected by electric generating systems which is typically discarded (often at some environmental cost) and wasted by central generating facilities.

   There is a considerable amount of overlap between equipment being developed for energy conservation and onsite generating devices, and onsite designs are usually most successful when integrated into a coherent plan encompassing both energy demand and supply.

2. The basic solar energy resource is available onsite whether it is captured or not.

   Integrating the equipment into the walls or roof of a building or into the landscape around a building can reduce the land which must be uniquely assigned to solar energy.

   Onsite generation of energy can reduce the cost of transporting energy and reduce the losses and environmental problems associated with transmission (although the extent of these savings can be difficult to compute).

3. Onsite equipment can reduce investment risks, because it can be constructed rapidly and additional units can be installed quickly to meet unexpected changes in demand.

4. Onsite equipment can be made as efficient as centralized equipment, even if no attempt is made to use thermal energy exhausted by generating devices; if this heat is applied usefully, overall efficiencies as high as 85 percent are possible.

5. High-efficiency energy use, possible with combined electric and thermal generation, can result in a reduction of polluting emissions produced by onsite devices burning conventional fuels.

6. Onsite equipment can be manufactured, installed, and maintained without major changes in the way energy-related equipment has been handled in the past; it would not require novel approaches to financing, new types of businesses, major new categories of labor skills, or major participation by the Government.

In addition, there may be social, strategic, or political reasons for trying to reverse the trend toward increasing centralization of energy production in the United States which have no direct connection with the economic merits of the case. For example, widespread use of onsite solar equipment could have a favorable impact on:

1. American labor--by creating attractive new jobs;

2. International stability--by easing the competition for conventional energy sources without increasing opportunities for proliferation of nuclear weapons;

3. The environment--by replacing polluting energy sources.

The use of solar energy in the future will depend largely on the value which society attaches to these, and other, advantages.

Integration

In assessing the relative merits of large and small equipment, it is necessary to judge both as part of an integrated energy system. Reviewing the performance of units operating in isolation can be very misleading.

While it is possible to construct onsite solar devices capable of operating with no connection to other power sources, it is seldom economically attractive to do so when other sources of power are available. It is tautological that designing an optimum approach for providing energy in a given region requires that all equipment for installing and consuming energy be considered as components of a single integrated energy system designed to meet a fixed set of energy demands: maintaining building interiors at comfortable temperatures, providing lighting, supplying heat for industrial processes, etc. Any attempt to simplify the problem by considering the capabilities of components in isolation must result in a less efficient outcome. Moreover, it is likely that without taking this synthetic perspective, some critical aspect of the overall system will be neglected.

Performing this kind of analysis is difficult because of the complex and highly interdependent energy systems which have emerged over the past few decades, the variety of equipment which is currently in use, and the bewildering variety of devices now under test and development.

The design of an optimum energy network which includes onsite solar facilities requires choices in the following areas:

1. How much of the backup energy should be supplied from energy storage equipment, and how much backup energy should be supplied from conventional energy sources? (This usually translates into determining the optimum size for onsite storage equipment.)

2. Should conventional backup power be provided from electricity generated at a central generating facility or from fossil fuels burned onsite? (It should be noted that it is possible to use chemical fuels--oil, gas, alcohol, coal, etc.--to backup even solar electric facilities since a small energency generator can be used when solar electricity is not available.)

3. If electricity is stored, should it be in thermal, mechanical, or chemical form?

4. Should the excess onsite energy be transmitted (in thermal, chemical, or electrical form) to a central or regional storage location or should it be stored where it is generated? (Energy generated at a centralized facility can be transported and stored in distributed storage facilities, and energy generated in distributed small facilities can be transported and stored in centralized storage facilities.)

5. Should control over the onsite storage and generating equipment be exercised from a central point?

If it is possible to transmit energy inexpensively, overall energy costs can usually be reduced by connecting together as many energy consumers as possible. If onsite generating systems are not connected, each generating unit (solar plus backup) would have to be large enough to meet the peak demand on the building or industrial process which it is designed to serve. The load factors of individual buildings are usually very unattractive. Onsite load factors can be as low as 15%, while typical utility load factors are 50 to 60%. Moreover, each onsite facility would have to provide enough redundant equipment to achieve acceptable levels of reliability. If an interconnection is available, however, it is necessary only that the combined output of all generating units in the system be able to meet the aggregate peak demand of the region. The aggregate peak will be lower than the sum of the individual peak demands since individual peaks will occur at different times (this is usually called "diversity" in the demand). The advantage of the connection is magnified by the fact that most generating devices operate less efficiently when operated to meet an unevern demand. Interconnections also permit greater freedom in selecting generating and storage equipment (onsite and centralized facilities can be selected as they are appropriate), and it is easy to optimize the efficiency of the total system throughout the year by controlling the performance of each system in the network in response to the total load.

The problem of uneven loads is a particularly difficult one in the case of electric utilities since generating and storage equipment tends to be extremely expensive, although chemical and thermal transport systems can also benefit from balanced loads. It may prove feasible, for example, to pipe hot water generated in collectors located on a number of separate buildings to a central thermal storage facility. If this storage facility is large enough, collectors need only have an annual output large enough to provide for heating and hot water requirements and storage losses. Such systems may require less collector area per building unit than conventional solar heating and hot water systems using relatively small amounts of storage.

While connecting energy generating and consuming devices into a single energy network can lead to significant savings, the transmission and distribution systems required can be extremely expensive. The costs of several types of energy transport systems are summarized in table V-1. Comparisons of this type can be somewhat misleading because costs will vary greatly from site to site, but the table at least allows a crude ranking of alternatives. It indicates, for example, that transporting energy in chemical form is by far the least expensive approach. It is interesting to notice, however, that distributing energy in the form of hot water over distances of 1 to 2 miles is only about 30% more expensive than transmitting electrical energy over typical distances from generating facilities to consumers. In this comparison, no attempt was made to share the cost of the trench dug for the hot water pipe with potable water, sewer, telephone, or other lines which could be placed in the excavation. The electric distribution costs would have been significantly higher if buried cables were used.

Table V-1.—A Comparison of the Cost of Transmitting and Distributing Energy in Electrical, Chemical, and Thermal Form

Mode	Capacity	Capital cost	Efficiency	Load factor(1)	Operation and maintenance	Usable energy cost(2)
Electric transmission . (765kV, 500 miles)(3)	8.1×10^{6} kW (3.25 lines equivalent)	$92/kW(4)	0.95(5)	0.7	$\$5.7 \times 10^{-4}$/kWh(6)	$\$5.2 \times 10^{-3}$/kWh(7,2)
Natural gas transmission ...... (30 inches diameter, 800 PSI, 500 miles)(8)	$8.1 + 10^{6}$kW (1 line)	$17.6/kW(9)	0.98(10)	0.88(11)	$\$3.8 \times 10^{-4}$/kWh(12)	$\$9.1 \times 10^{-4}$/kWh(13)
Electric distribution... (10,000 customers—residential/commercial)	5×10^{4}kW (17.2×10^{3}kWh per customer)(14)	$130/kW(15)	0.94(5)	0.4	$\$9.3 \times 10^{-4}$/kWh(16)	$\$9.0 \times 10^{-3}$/kWh(7) (Total electricity = 0.0142)
Natural gas distribution .... (10,000 customers—residential/commercial)	8.3×10^{4}kW (121 Mcf per customer)(17)	$50/kW(17)	0.98(10)	0.5	$\$3.8 \times 10^{-4}$/kWh(18)	$\$2.0 \times 10^{-3}$/kWh(13) (Total gas = 0.00291)
Hot water distribution........ (10,000 customers—residential/commercial)	7×10^{4}kW(19) (21.3×10^{3}kWh per customer)	$260/kW (19,20)	0.85(19)	0.35	$\$2.6 \times 10^{-3}$/kWh(21)	$\$1.8 \times 10^{-2}$/kWh(7)

NOTES:

[1] A capital recovery factor of 0.15 is used to calculate annual capital charges.

[2] Assumes a capacity of 2,500 MW for one 765 kv line.

[3] Utility construction expenditures of $1.7 billion in 1975 for 3,782 additional miles or $461,000 per mile average. (*Statistical Yearbook of the Electric Utility Industry for 1975*, Edison Electric Institute, New York, N.Y., Oct. 1975.)

[4] *The 1970 National Power Survey*, Federal Power Commission, Washington, D.C., p. 1-13-8, Dec. 1971.

[5] Investor-owned electric utilities spent approximately $850 million on transmission O & M costs in 1975 for 1.5×10^{12} kWh. (*Statistical Yearbook of the Electric Utility Industry for 1975*).

[6] Assumes an end-use efficiency of 100 percent.

[7] *National Gas Survey*, U.S. Federal Power Commission, Vol. 1, p. 34, 1975.

[8] All natural gas companies spent $531 million in 1976 for 1,845 miles of new transmission pipeline or $287,000 per mile average. (*1976 Gas Facts*, American Gas Association, Arlington, Va., 1977).

[9] Four percent of total natural gas consumed was used for pipeline fuel in 1976. This is equally allocated to transmission and distribution. (*AGA Gas Facts*).

[10] *National Gas Survey*, U.S. Federal Power Commission, Vol. III, p. 129, 1973.

[11] All natural gas utilities spent $1.1 billion in 1976 on O & M for transmission for 14.8 trillion cubic feet (TCF).

[12] Assumes end-use efficiency of 65 percent.

[13] "Residential Energy Use to the Year 2000: Conservation and Economics," Oak Ridge National Lab, Report ORNL/CON-13, Oak Ridge, Tenn., Sept. 1977.

[14] Investor-owned electric utilities spent $2.8 billion on construction of distribution facilities for 21,700 kW of new capacity in 1975. (*Statistical Yearbook of the Electrical Utility Industry for 1975.*)

[15] Investor-owned utilities spent approximately $1.59 billion in 1975 for distribution O & M costs for 1.5×10^{12} kWh. (*Statistical Yearbook of the Electrical Utility Industry for 1975.*)

[16] Calculated from the average cost of $400 per customer (private communication—American Gas Association) with an average hot water and space heating requirement of 36.4×10^{3} kWh (121 MCF) per year and an assumed load factor of 0.4.

[17] All natural gas utilities spent $1.1 billion on distribution O & M in 1976 for 14.8 TCF (*AGA Gas Facts*).

[18] See volume II.

[19] "Evaluation of the Feasibility for Widespread Introduction of Coal into the Residential and Commercial Sectors." Exxon Research and Engineering Co., Linden, N.J., Vol. II, p. 6-11, Apr. 1977. These two studies give a construction cost of about $14 million for the size system in question, which requires a peak capacity of 70,000 kW, as shown by reference in note 20.

[20] Annual O & M costs are calculated by assuming they are 3 percent of capital costs, which is the average of the percentages for gas and electric systems.

[21] The cost of energy lost in transmission was estimated using 0.04c/kWh for electricity and 1.5c/kWh for thermal energy.

UTILITIES AND SOLAR COMMERCILIZATION

Utility participation in onsite generating facilities offers several advantages:

1. The utility is in the best position to optimize the size and placement of all generating, storage, and transmission equipment in the region;
2. Utilities alone can compare the cost of energy from new onsite equipment with the cost of energy from new central facilities--all other owners will compare onsite costs with the lower, average cost of energy from all central generating facilities;
3. Utilities can offer the equivalent of 100% financing for new generating plants (onsite or otherwise) and are able to raise capital for investments with long-term paybacks--something which few other institutions can do;
4. Utilities already have maintenance crews and billing services, which could be expanded to cover the operation of onsite generating equipment.

A number of these advantages could be realized without utility ownership of onsite systems if care is taken in the design of utility rates. There should be no difficulty in constructing equipment capable of providing power to utilities which meets utility standards of voltage regulation and frequency control. One manufacturer (Gemini Company) of small inverter systems has sold (as of 1980) 65 units which are integrated into utility systems, and quality of power has not been an issue.

Municipal utilities may be able to play an important role in regional planning for onsite solar energy systems and their access to relatively low-cost capital may make municipal financing of solar energy projects attractive.

Utility Attitudes

There is no industrywide position either on the issue of onsite generation or on the question of utility ownership of such facilities. Industry attitudes vary company by company, and the diversity of attitudes is due, at least in part, to the fact that many utility companies simply have not taken a close look at the issue.

Natural gas utilities have expressed the greatest recent interest in onsite solar facilities since supplies of gas are diminishing and the companies are looking for new energy sources to replace natural gas in the future. Southern California Gas Company, for example, has tested solar assisted gas heating for apartment buildings as one means of conserving supplies and extending the life of the company's resources. Interest is not confined to gas companies. A recent survey found nearly 100 electric utilities which were initiating projects in solar heating and cooling. The Electric Power Research Institute has an extensive program in solar energy equipment. At least one electric utility has entered into an agreement with a local installer of solar hot water heaters, and a gas utility has proposed changes in regulations that would permit it to operate as a combined gas and solar utility.

On the other hand, most of the utility companies surveyed for a General Electric study said they were reluctant to enter the business of selling thermal energy systems. Some indicated that it would require too much diversification; others cited problems with metering and other technical difficulties.

A study conducted for the Federal Energy Administration found mixed opinions among utilities on expanding capacity by using conventional onsite generating equipment, primarily cogeneration systems in factories and other generators of process heat. Examples include:

1. A west-south-central utility which sells both steam and electricity.
2. A Pacific coast utility, which has installed turbines at a paper mill, returns low-temperature steam to the mill and pays $0.01 per kWh for electricity generated.
3. A Vermont utility actively searching for cogeneration opportunities.
4. A Texas utility which stated flatly that they were "not in the business of selling steam", and which turned down several opportunities.

Although utility attitudes may be changing, there have been scattered complaints that utilities have tried to thwart private companies intending to install onsite generating equipment. The Dow Chemical Company reports that onsite industrial cogeneration "has been consistently discouraged by long-standing policies on the part of most privately owned electric utilities that have discouraged in every way possible the generation of electricity by any other type of organization. Relevant here are rate schedules that favor large industrial users (whether justified or not by "cost of service"), and heavy demand charges (charges levied even if no power is used) and that makes it uneconomical to use the utility as a standby source backing up industrial power generation".

Energy Generation

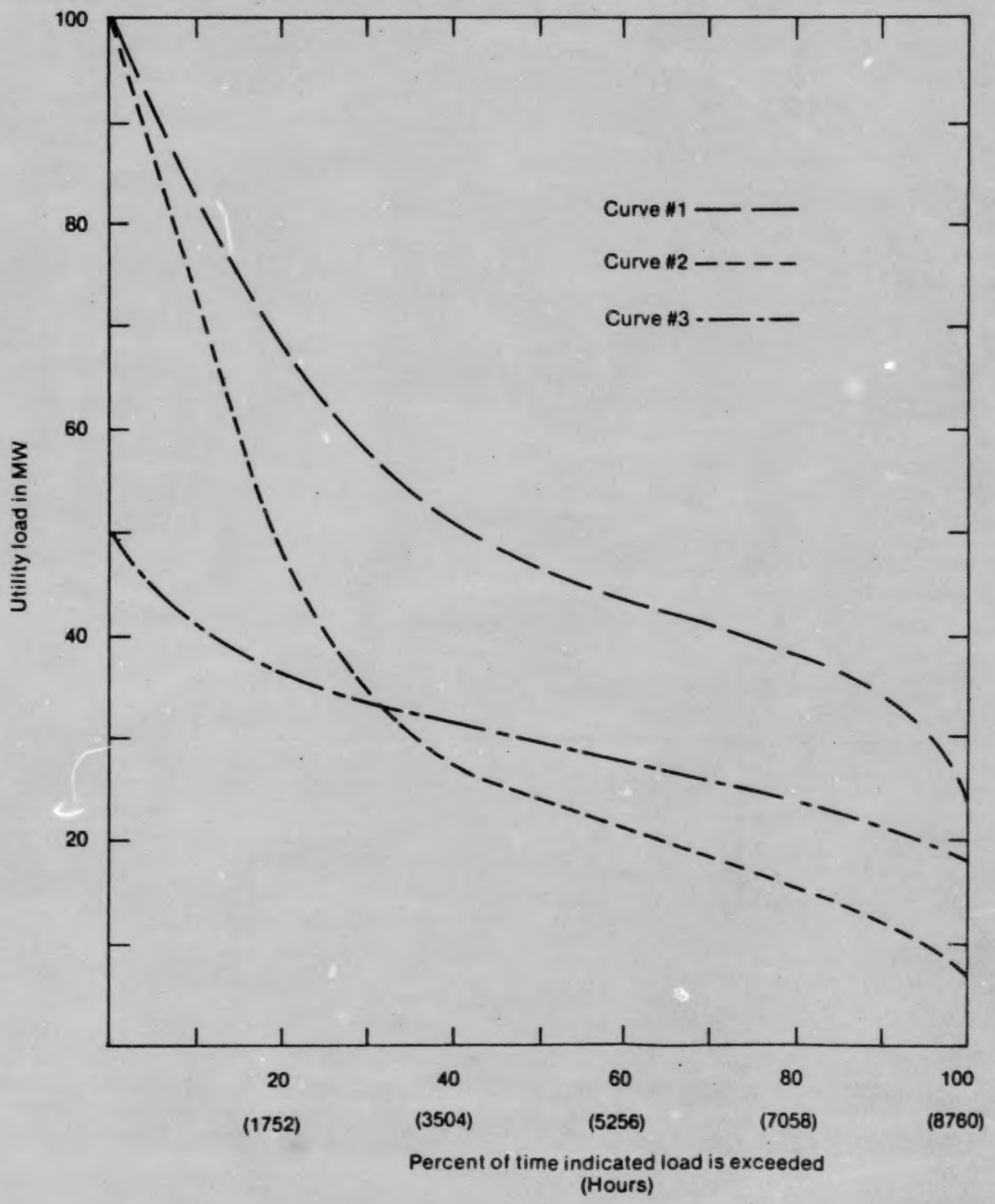
Electric utility load patterns can be most conveniently summarized in what is known as a "load-duration curve". The curve for a hypothetical utility is shown in figure V-A-1. It shows the number of hours per year the demand for electricity is greater than or equal to all demands from zero to the annual peak. For example, the figure shows that the power company in question had a maximum load of 100 MWe and a minimum load of 25.0 MWe (i.e., the company produced at least 25.0 MWe for all 8760 hours of the year). The company met a load which was greater than or equal to 50 MWe for at least 3504 hours during the year. Loads will increase with each new year as a result of population growth and increases in the electricity consumed by each person. The increase in per capita consumption is a result of a shift to electric heating and other electric appliances.

If solar equipment is installed in a significant fraction of the buildings served by a utility, the load pattern which it must meet could be significantly affected. Figure V-A-1 illustrates two extreme possibilities. It is assumed that curve 1 indicates the load-duration curve which a utility could expect if no solar equipment were installed. If solar equipment requiring supplementary power during a utility's peak demand hours was installed, a load-duration curve having roughly the shape of curve 2 would result.

The amount of electricity sold would consequently be reduced, but costs would not be reduced proportionately because a large fraction of utility costs are independent of the amount of electricity generated. In this case, a utility will have proportionately more peaking plants with relatively small capital costs. Unfortunately, such plants are less efficient than large plants in both their fuel consumption and operating and maintenance expenses. Curve 3 indicates a situation where the solar equipment installed does not require supplementary power during the utility's peak demand hours. In this case, more efficient generating facilities (baseload plants and cycling plants) would be used to produce a greater fraction of the total utility load, resulting in a lower cost for each kilowatt-hour generated.

In order to quantify both the extent of the impact and whether it is adverse or beneficial, it is necessary to construct a "typical" utility. From this, several load-duration curves for the utility's operation can be constructed for, say 1985, involving a variety of scenarios both with and without solar equipment. These hypothetical load-duration curves can then be used to determine the kinds of equipment utilities will have to install to meet the demand of their customers, and the load factors for each piece of generating equipment. In turn, electricity costs and the utility's fossil-fuel requirements can be estimated for each scenario.

Figure V-A-1.—A Typical Load-Duration Curve for an Electric Utility



Source: OTA.

Storage Strategy

Onsite solar electric devices integrated into electric utility grids provide a good example of some of the difficulties which can arise from local control over storage equipment. A solar electric system which is not connected to a utility grid would charge its batteries during the day and discharge its batteries during the night. This is precisely the wrong strategy of operation from the perspective of the electric utility since storage devices owned by the utility would be charged during the night, when demands are low, and discharged during the day when demands are greatest.

There will be some overlap between the two operating strategies since both types of storage would be discharging near sunset and during cloudy days, but it is clear that the storage equipment would be used to best effect if it were controlled by the utility. The advantage of using the solar electric devices to meet utility electric demands directly during the day (instead of sending it to be stored) is amplified by the fact that storage devices are typically only about 75-percent efficient. This logic could apply even is a very large fraction of the utility's energy were derived from solar sources, although in this case the strategy of operating individual storage systems would closely parallel the operation of utility storage.

Economic Dispatch

Electric utilities now control the scheduling of their generators via computer. This optimizes the efficiency of their entire system on a minute-to-minute basis throughout the day. As long as a relatively small number of a utility's customers are using solar equipment which can generate electricity, no large-scale shift is necessary in current economic dispatch practices. The net load to the utility would fluctuate throughout the day, but current equipment and management schemes are adequate to handle the relatively large fluctuations that already occur with daily cycles, local weather variations, and industrial energy consumption. The utilities interviewed by the General Electric Company indicated that special dispatch strategies would not be required, even if onsite generating devices were installed by 10 to 30% of their customers.

The Dow Chemical Company's examination of industrial cogeneration was "unable to identify any problems or potential problems of transient stability attributable to dispersed industrial generation. The effect of dispersed generation close to load centers is to improve system integration and stability problems". However, if dispatching or system stability became a problem, the difficulty could be resolved by using interruptible service devices. When onsite users were producing too much energy for a utility's needs, the onsite devices could simply be disconnected from the load. (The cost of this could be included in the $100 per unit cited for interruptible services meters.) It is also possible that economic dispatch of electric utilities could improve if a number of onsite generating facilities were equipped with sufficient onsite storage of a fossil backup system. Dispatch is not a problem for systems relying on chemical fuels for backup.

Load Management

The performance of isolated and interconnected energy systems can be improved if control is exercised over devices which consume energy as well as over energy storage and generating equipment. Clearly, energy consumers will want to exercise as much discretion as possible over the amount of energy they use and when they use the energy, but they also may be willing to change their consuming habits to some extent if they are required to pay large premiums for energy consumed during periods when energy is relatively expensive to produce. Consumers may be willing to postpone or defer the use of appliances such as diswashers, disposals, clothes washers and dryers, and other equipment when electricity is expensive.

The utility can exercise control through the use of "interruptible service" equipment when onsite equipment includes onsite storage. Such devices would permit the utility to turn off water heaters and other appliances with storage capabilities during periods of peak demand. Equipment of this type has been installed for relatively large-scale testing by the Detroit Edison Company. If this equipment could ensure that onsite generating equipment (whether thermal or electric) purchases backup power only during offpeak periods, the cost of backup energy to the onsite customer might be reduced--perhaps to the point where energy could be bought and sold at the same rate. An experiment was recently conducted in Vermont in which these appliances were automatically turned off when utility rates were high. The customers were able to switch them back on again, but in most cases were willing to wait until rates fell. Well-insulated water heaters and freezers are able to operate effectively even if their supplies of electricity are automatically shut off during the day when electricity prices are high. Several cities in Germany have utilities which are able to exercise elaborate control over energy-consuming equipment. The central load-management computer can control both the generating equipment and electricity-consuming devices. The computer sends a signal down the electric wires which automatically shuts off industrial equipment, refrigerators, water heaters, and other equipment where energy use can be deferred during peak periods.

As was the case with the control over storage, however, the strategy of deferring demand for energy will depend strongly on how the solar devices are conntected with other energy equipment. If the solar device operates in isolation, an attempt should be made to shift all demands for energy to periods when the sun is shining. If an electric utility is used for backup power, however, it will usually be preferable to shift the demands which would require backup power to the late evening.

Offpeak Electricity

It is sometimes argued that electric utilities will be able to sell "offpeak" electricity at a rate which covers only the cost of operating a large "baseload" plant and the relatively inexpensive fuels which can be used in these plants. Such rates are possible, but they must be considered promotional since, in effect, they subsidize the price of electricity during the night by charging daytime customers for all other utility costs. These costs are capital charges on generating plants and transmission and distribution systems, the costs of maintaining the transmission and distribution lines, and all other overhead costs--including the added cost of maintaining dual meters for daytime and nighttime rates.

It is also important to recognize that there is not an unlimited supply of "offpeak" power available in a given utility. There are many possible uses for the power available at night, in additiion to storing heat for buildings. The power can be used to charge batteries for electric vehicles and in other industrial procedures which can be deferred to use night rates. The utilities may find that they require the "offpeak" nighttime energy themselves to charge their own storage devices, if utility storage must be used as a replacement for the oil- and gas-fired generators now used to meet utility peaks. (The National Energy Plan places major emphasis on eliminating utility use of oil and gas.) And utilities must also make some use of offpeak periods to maintain their equipment.

Transmission and Distribution of Electrical Energy

Electric transmission and distribution is an expensive undertaking. Over half of the capital invested by electric utilities in the United States is invested in a massive network of transmission and distribution equipment. In recent years, the ratio between capital investment in electric generating, transmission, and distribution equipment has fallen because of the rapid increase in the cost of generating plants (see table V-2). Each dollar now invested in generating equipment is accompanied by a 16¢ investment in transmission equipment and a 23¢ investment in distribution systems. The high cost of the electric transmission and distribution system is due in part to the fact that the lines have relatively low load factors.

The electric transmission and distribution lines now in place are typically 90% efficient, but it is hoped that improved technology will lead to overall efficiencies of 92.5% by the year 2000. The improved efficiency, however, will most likely add to the capital cost of the systems.

The cost of maintaining transmission equipment can also be substantial. In 1974, the cost of operating and maintaining the network of electric transmission and distribution lines owned by privately owned utilities in the United States exceeded the cost of operating and maintaining the generating facilities (fuel costs excepted).

In addition to direct costs, transmission lines can have serious environmental consequences. It is estimated that over 3 million acres will be required for new transmission lines by 1990. Much of this construction will occur in scenic areas where opposition is likely. In addition, it is possible that the large electric fields produced by high voltage transmission lines may be harmful. The question is being investigated and the results are inconclusive at this time.

Table V-2.—Construction Expenses of Electric Companies

	1965	1967	1969	1971	1973	1975	1977
Total investment (billions of dollars)	4.03	6.12	8.29	11.89	14.91	15.09	19.50
Production equipment (%)	32.3	41.7	48.1	56.3	58.9	65.1	68.3
Transmission equipment	23.3	21.5	18.7	15.2	13.7	11.5	10.7
Distribution equipment	39.4	32.3	29.2	23.3	22.6	18.7	15.7
Other	5.0	4.4	4.0	5.1	4.8	4.7	5.03

SOURCE: EBASCO 1977 Business and Economic Charts (Ebasco Services, Inc., New York, N.Y.)

Transmission and Distribution of Thermal Energy

Hot water and steam distribution systems used for heating buildings typically have load factors of 33% (see table V-1). Information on the efficiency of hot water and steam transport systems is not available. Losses are a strong function of the ground and fluid temperatures, the distances traveled, and the average size of the pipelines. Some recent steam distribution systems, however, have experienced losses on the order of 15 to 20% and have created serious difficulties for the systems relying on them.

The cost of maintaining transmission equipment can also be substantial. Annual maintanance costs for a small hot water distribution system can amount to about 3% of the initial capital cost of the equipment. Maintaining steam systems may prove to be significantly more expensive.

Most hot water and process steam is consumed close to where it is generated, but a number of cities have systems for distributing steam to residences and industries. In the United States, many older systems have been abandoned, and few new systems are being built. The Modular Integrated Utilities System (MIUS) in Jersey City, N. J., is one of the few recent exceptions to this trend. The abandonment of steam distribution is due mostly to the overall decline of onsite generation. This tendency is reinforced by the fact that many older steam-distribution systems were not designed to return water to the generating plant, as the turbines operated on untreated water. This procedure became impractical with the addition of large,high pressure, steam-generating facilities requiring expensive water purification systems. Table V-3 estimates the capacities of district heating in the United States and abroad. On the other hand, district heating has been used much more extensively in Europe. For example, 30% of the residences in Denmark are connected to district heating systems. Sweden estimates that 70% of its multifamilty units and 20% of its single family homes will be connected to district heating systems by 1980. West Germany plans to provide district heat to 25 to 30% of its dwellings by 1980.

The feasibility of using district heating systems depends much on the density of dwelling units. A study conducted in connection with the MIUS project estimated that a garden apartment complex in the Philadelphia area (60 buildings with 12 apartment units per building) would cost about $410 per unit for heated water distribution and $330 per unit for chilled water. A MIUS system was actually installed in Jersey City, N.J., for approximately this amount. A preliminary estimate of the cost of a large district heating system capable of serving a community of 30,000 people in a mixture of apartments and single family units indicates that the cost per unit for this dispersed system would be nearly three times as great. The ability of a system to amortize these costs depends on the cost of the energy supplied and the yearly energy demand of each building. A rule-of-thumb applied until recently in West Germany was that a "breakeven" housing density was one which required 44 MW_t/km^2 for existing urban areas and 28 MW_t/km^2 for new developments. Recent increases in fuel prices, however, have led them to consider areas with demands as low as 14 MW_t/km^2. The garden apartments in the MIUS study had a demand of approximately 30 MW_t/km^2.

Transmission and Distribution of Chemical Energy

Gas pipelines are typically 90% efficient, the losses being due primarily to the fact that gas is withdrawn to run pumps in the pipeline. The cost of maintaining transmission equipment can also be substantial. A summary of the costs for transmitting and distributing energy in chemical form is contained in Table V-1.

Table V-3.—District Heating Systems

District Heating Systems in the United States

	44 city systems	New York
Total steam sold (millions of pounds)	84,246	32,702
Total steam delivered to system (millions of pounds)	96,672	38,469
Annual system load factor	33%	37%
Number of customers (in thousands)	14,903	2,514
Length of distribution system (in miles)	573	100
Installed air-conditioning (tons)	666,051	569,945

Note: New York City has the largest American system, selling nearly 10 billion kWh per year. The load is 30 percent residences, 45 percent office buildings, 11 percent industries, and 13 percent institutions.

SOURCE: *Official Proceeding*, 60th Annual Meeting of the International District Heating Association, June 1969, pp. 22-30, quoted on p. 24 of ORNL-HUD-19, ibid.

District Heating Abroad

	Sweden (1973)	Denmark (1973)	W. Germany (1973)	U.S.S.R. (1971)
Energy sold for district heat (millions of kWh)	12	14	38	1,100,000
Units connected	600,000	30% of dwellings	83,000	75%

SOURCES: I.G.C. Dryden, *The Efficient Use of Energy*, IPC Science and Technology Press, 1975, p. 369.
Quoted in Teploengetika, Vol. 18, No. 12, 1971, pp. 2-6.
W. Hausz, and C. F. Meyer, "Energy Conservation: Is the Heat Storage Well the Key?" *Public Utilities Fortnightly*, April 24, 1975.

Metering

No major technical barriers need to be overcome in designing meters or onsite energy equipment, but new types of meters may have to be developed for this purpose. If a utility owns onsite equipment with thermal output, some technique must be found for billing customers for the energy produced by the onsite device. One utility has suggested that the simplest technique would be to bill a customer on the basis of actual capital and maintenance costs, although meters capable of measuring the energy generated by solar thermal systems of various sizes are available. For example, the Electron Advancement Corporation sells meters measuring 140° to 150°F water at flow rates of 30 to 100 gpm at a price of $400 to $500 (price list Feb. 9, 1977). An electric utility in Florda is using such Btu meters on solar hot water heaters installed under its auspices.

The metering problems of onsite electric generating systems depend on the nature of the customers relationship with the local utility. If the utility is willing to purchase energy at the same price as it sells energy to onsite users (or if it owns the generating equipment itself), it may not be necessary to charge metering systems--because conventional meters can subtract from the net energy account when energy is purchased. This practic is currently permitted in several New England States on an experimental basis. In cases where energy is sold at a different price from that purchased, dual meters will be required--with one ratchet to read sales to the customer and one ratchet to read purchases from the customer.

Local Distribution Capacity

One potential technical difficulty, identified in the General Electric study, is the possibility that onsite units which feed electricity back into the power distribution grid would exceed the capacity of the lines and transformers serving the area. It is unlikely that onsite units would produce excess power for sale at a rate high enough to exceed the peak purchases of the onsite customer. There could be some problems in older communities, where distribution systems were installed without considering the possibility that a substantial number of residences might be equipped with all-electric systems. A typical distribution system, however, should be able to accommodate the output of residential photovoltaic systems without major changes in transformers or lines.

RATES AND COSTS

The price a customer pays for electricity seldom directly reflects the cost of producing it. In the absence of widespread time-of-day metering, billings are usually based on formulas that allocate peak costs of energy and total montly consumption according to the historical demand patterns of different categories of customers.

Declining Block Rate

The most common residential electric rate is the "declining block rate", under which customers are charged a fixed fee for monthly service, with declining rates for each incremental block of energy consumed beyond the amount covered by the fixed fee. For example, the formula might call for a charge of $3 for the first kilowatt hour (kWh), $0.04 per kWh for the next 100 kWh, and $0.03 per kWh for the next 200. The declining block rate was introduced when marginal costs for electric utilities were declining and utilities were encouraging customers to use more electricity. Another frequent practice, designed to increase sales of electricity, is to reduce rates if a house or commercial building is "all electric".

Utilities justify using these rates in today's market by arguing that all-electric customers are more likely to use electricity during the night for heating and cooling than are other types of residential customers, who use electricity for lighting and other purposes during peak hours. The wisdom of continuing a promotional rate schedule in a period of declining energy reserves, however, has been seriously questioned in many quarters. President Carter's proposed National Energy Plan would have flatly prohibited declining block rates.

Declining block rates can discourage the use of onsite solar power because a large part of a customer's utility bill is based on the first few kWh delivered, power which would probably not be replaced with solar energy.

Peak Demand

Larger utility customers are frequently charged on the basis of their "peak demand" during some specified period. Such rates are designed to achieve a more direct relationship between consumption and the net generating capacity that must be installed to meet the customer's requirements. Techniques for determining peak demand vary greatly. Some utilities charge according to the peak demand during the previous 6 months, some take the lesser of monthly peak demands, and some percentage of annual demand, and others charge on the basis of spot measurements of demand made without advance notice.

The impact of such demand rates on customers with onsite facilities can be very great. In some cases, a demand charge could be so high that a purchase of energy at high rates, when onsite equipment failed or when cloudy weather persisted, could negate any savings attributable to the onsite equipment for an entire year. The justice of such charges is a difficult issue to resolve. Providing power to backup random failures of onsite equipment among a large number of small customers can clearly be managed without a large increase in a utility's generating capacity. Relatively high backup charges might be justified, however, if all of these customers abruptly demanded backup power during a prolonged stretch of adverse weather.

Some utilities have considered applying demand charges to residential customers to cover some of the market losses that would be inevitable with widespread installation of onsite solar generators. One such proposal by the Public Service Co., a Colorado utility, was fiercely opposed by solar customers, who calculated that under such a rate structure a solar heating system that reduced energy requirements by 70% would reduce electric bills by only 35%. The Colorado Utility Commission initially granted the utility's request for the rate change, but reversed the decision following a rehearing and ruled that the issue was sufficiently complex to be addressed in a generic rate hearing.

Standby Service

Still another rate structure is designed to provide standby service to customers who do not use electricity under normal circumstances, although these rates would not apply to solar customers under the current definition of "standby power". If the definition were changed to cover onsite facility owners, however, the high minimum monthly charge associated with standby rates would not be advantageous to customers with onsite solar facilities.

Lifeline Rates

Lifeline rates have been adopted in a few states. Under this system, the charge is low for the first units of energy. The goal is to ease the burden on low-income consumers. Some authorities, however, question whether the lifeline concept is an effective method to aid lower income groups since these persons often consume realtively high amounts of energy.

This rate may incidentally benefit solar users whose needs for supplemental sources of energy are small enough to fall within the "lifeline" amount.

Interruptible Rates

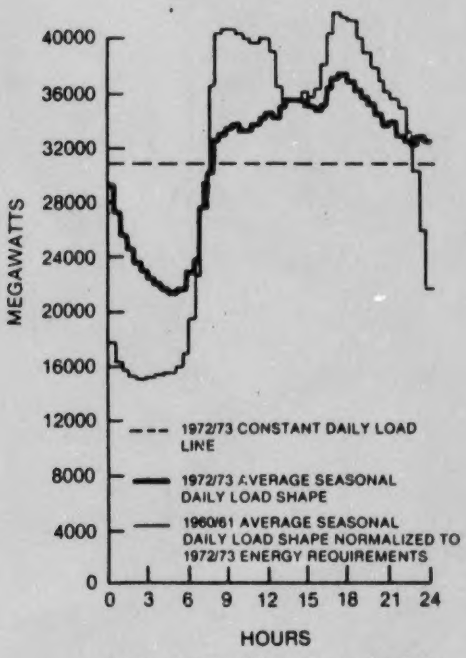
Another type of utility pricing is interruptible rates. This traditionally has been available only to industries willing to accept the risk of service interruptions in return for lower costs. Some studies have pointed out that a solar user willing to accept the risk of going without utility service on infrequent occasions could save the utility substantial amounts in capital requirements, justifying a lower rate. If the peak occurred only rarely, this alternative might be considerably less expensive than additional units of storage or collector area. The National Energy Plan proposes that utility companies be "required" to offer interruptible rates to all customers.

Time-of-Day Pricing

Some of the advantages of connecting energy generating and consuming devices with a common energy transport system cannot be realized if control over the equipment is not exercised by a central authority capable of optimizing the performance of the integrated system. This control can be exercised directly by a utility if it owns all of the storage and generating equipment in a system, but it can be exercised indirectly by such approaches as time-of-day pricing. For example, with time-of-day pricing, the costs of non-optimum performance of equipment not owned by the utility would be communicated to the owners of this equipment through higher prices for energy consumed for backup power and lower rates for any energy sold to the utility. The electric rates now in effect in most parts of the United States, however, do not have the effect of enforcing optimum allocations between onsite and centralized generating equipment. In fact, many of the current rates tend to discourage onsite generation in spite of potential cost savings.

Figure V-1 illustrates the dramatic change in electricity consumption in Great Britain which occurred after a time-of-day electric rate was imposed. Before the rate was introduced, very little electricity was consumed during the night and an enormous increase occurred in the morning when electric heaters and other equipment were turned on. After the variable rate was introduced, many consumers purchased onsite thermal storage devices which could be charged during the night and used to heat buildings during the day. The result was a much more uniform pattern of energy consumption.

Figure V-1.—Improvement in the Pattern of Electricity Consumption in England's South Western Electricity Board Resulting From a Shift to Time-of-Day Electricity Rates



Winter-average Weekday Load Curve

SOURCE:
Ashbury, J.G. and A. Kouvalis, *Electric Storage Heating: The Experience in England and Wales and in the Federal Republic of Germany*", Argonne National Laboratory, Energy and Environmental Systems Division ANL/ES-50 1976 p. 14

Selling Energy to a Utility

As of today, few utilities are willing to purchase power from customers, although special arrangements have been made with several large industrial customers. In some cases, the price the utility pays for surplus power reflects only the cost of the fuel the utility would burn to generate an equivalent amount of energy. In other cases, the price reflects both fuel costs and the cost of equipment the utility would have to install to generate the power. However, there are so few arrangements for sale of surplus power that clear patterns are difficult to identify. Southern California Edison Co., for example, recently proposed a rate schedule under which it would buy energy from large industrial customers at "the lowest cost of energy provided by any generating equipment in the Bonneville Power District". This is about 3 mills per kWh, a rate that reflects a minimum energy displacement fee. However, in the same proposal the utility offered to purchase energy from a limited number of residential and small commercial facilities at a rate that is essentially identical to the rate the utility charges residential customers. The Gemini Co., which sells devices to connect onsite wind generators and other equipment to utility distribution lines, identifies widely varying patterns of proposed surplus-power prices. Some New England utilities are willing to buy electricity at their own sales price because fuel represents a large fraction of their overall costs. Utilities with low baseload fuel costs have been more reluctant to buy surplus power.

REGULATION AND CONTROL

State laws and regulations governing the relationship between private and public utility companies and the owners of onsite generating equipment are complex, and frequently ambiguous, largely because these problems have seldom been addressed by regulatory commissions. In the small number of cases where utilities and industries exchange electrical power or process heat, contracts have generally been written in ways benefiting both parties so that no lawsuits have been brought forcing the courts to rule on ambiguities in the law.

Perhaps the most crucial question in utility regulation is whether utilities may adopt rates or service policies that unfairly discriminate against solar customers requiring utility power as backup.

The answer appears to be that current laws will permit discriminatory rates for solar customers if the utility can prove that the cost of providing service to solar customers exceeds the cost of providing service to other customers. Although it cannot arbitrarily set prices or refuse service in an effort to eliminate competition from solar devices, the burden of proving such discrimination may fall on the solar customer.

Difficulties are likely to occur only when an electric utility is involved, since gas utilities would, in general, not be adversely affected by a need to provide backup service to onsite facilities. Calculating a rate for both the purchase and sale of electric energy to a utility is an extremely complex problem.

Regulations Covering Discrimination

The rates summarized previously were, except for Colorado, not designed to discriminate against solar equipment, although their impact is not diminished by the lack of an intent to discriminate. One of the major purposes for public regulation of electric utilities is the prevention of unreasonable discrimination or undue preferences. Nearly every State has a statute prohibiting conduct that favors one class of customer while harming another. Typical statutes proscribe policies that are "unreasonable", "unjust", "undue", or "unlawful". Discrimination is a question of fact to be determined on a case-by-case basis by the State utility commission, and it is very difficult to predict precisely how any given discriminatory practice will be analyzed.

As previously shown, determining fair rates for electric utility power is an extremely difficult process. Uneven solar demands on the utility can result in realtively poor utilization of expensive generating and transmission equipment, but it must be recognized that demands imposed by many nonsolar customers are also very irregular; the only fair measure of the cost of providing backup power to an onsite solar facility is to accurately compute the marginal utility costs incurred in providing such backup.

The parallel question involving a determination of the rate which the utilities can be expected to pay for excess onsite power offered for sale is equally difficult; several very sensitive issues must be resolved. For example, how should the costs of transmission lines be allocated between the price of utility sales and the price charged by onsite generators. Should the utility be expected to purchase energy at rates reflecting the marginal cost of providing the same amount of energy from new utility equipment or simply for the average cost of utility power generated. It will usually not be possible for utilities to pay a rate high enough to meet typical industrial revenue requirements on capital invested in new energy projects. It is possible, however, that special rates could be established which would permit utility purchases at required rates, and it also is possible that, if a utility could sign a contract with a firm guaranteeing purchases over 10 to 20 years, the firm could accept a smaller rate of return on funds invested in the generating equipment.

In general, the cases and State utility decisions suggest that utilities have substantial freedom to treat different classes of customers differently. Two general principles emerge: (1) preferential treatment is more acceptable if it produces indirect benefits to all customers; and (2) utilities may treat customers differently if there is a reasonable economic basis for doing so, that is, costs to the utility are clearly different. For example, discrimination in favor of solar users that would reduce rates for all customers by reducing the utility's costs would be acceptable.

It seems clear that public utilities may discriminate either against or in favor of onsite solar users if the discrimination either benefits all customers or is based upon a reasonable economic basis. Discrimination could be either as service practices (e.g., specific times at which backup power could be used) or as rate practices (e.g., higher rates for less energy use).

A public utility is subject to State regulation in addtion to anti-discrimination laws, by virtue of being a public utility. Fundamental to the concept of a public utility is its dedication of property to serve the public without discrimination. Almost every State has a statutory provision requiring utilities to "furnish adequate and safe service", "provide such service, instrumentalities, and facilities as shall be safe and adequate and in all respects just and reasonable" or "furnish reasonable adequate service and facilities".

A public utility "may not pick and choose, serving only the portions of the territory covered by their franchises which it is presently profitable for them to serve". As with most issues in public utility regulation, the duty-to-serve requirement is interpreted on a case-by-case basis with "reasonableness" and the "public interest" as the touchstones.

A public utility cannot refuse to provide backup power to onsite facilities unless it can demonstrate a compelling case that backup service would cause substantial harm to the utility's existing customers. Refusal to provide service would violate not only Federal antitrust laws, but also the utility's common law and statutory duty to provide utility service. Of course, the duty to provide adequate service has some limits; utilities may be excused from providing service when prevented by acts of God, labor disputes, and shortages of fuel supply. In some cases, utilities have been excused from providing service where to do so would be unusually expensive, although there is substantial precedent to the contrary.

These laws would not, however, prevent adoption of a policy which would discriminate against new utility customers who did not use solar equipment. Existing statutes appear to permit a regulation which would prevent a utility from providing new service to a customer not using solar energy equipment.

Some States have taken measures to restrict gas to certain customers or to eliminate its availability for some uses. For example, New York banned the use of gas in swimming pools and in buildings without adequate insulation. A few States have banned its use in decorative lighting.

The legal principles involved in rate regulation are similar to those discussed for service discrimination. The same prohibitions on discriminating among customer categories apply, as to the ambiguities as to what constitutes "discrimination".

A rate structure that adversely affects solar energy users, however, may be difficult to challenge under current case law. Several cases have upheld the legality of rate structures that subsidize a particular class of customers (all-electric customers) despite antidiscrimination laws. In 1965, a court interpreted an antidiscrimination statute as barring only "unjust" discriminations, and concluded that only arbitrary discriminations are unjust:

> If the difference in rates is based upon a reasonable and fair difference in conditions which equitably and logically justify a different rate, it is not an unjust discrimination.

Part of the difficulty results from the fact that the utility can argue that its cost structure justifies a discriminatory rate and the challenger is hard-pressed to rebut the extensive analysis which can be conducted by the utility about its unique cost structure, although in cases requiring a calculation of a fair backup charge for solar energy (and a fair price to pay for excess onsite energy) utilities can be confused as the interveners.

Until the late 1960's, cost per unit of electricity for at least some types of powerplants declined steadily. Utilities could therefore argue that promotional rate structures would, over time, bring new businesses that would justify additional powerplants. These new plants would then lower the bills of all customers of the utility. More recently, the lack of new sites for low-cost hydroelectric power, changes in regulatory practices, and increased environmental costs have forced the cost of new power to rise steadily.

In these circumstances, promotional rates lose much of their appeal. A New York court recognized the common impact of rising fuel prices in a recent decision overturning a subsidy for all-electric homeowners. The subsidy, which was to run for a year, was intended to lessen the impact of higher electric rates on residential customers who had previously been induced to buy all-electric homes by favorable rates. The court held that the subsidy "constituted undue preference and advantage" in violation of the State antidiscrimination laws.

Several utility commissions have already authorized programs to finance the installation of insulation to conserve natural gas. Since it can be reasonably claimed that conservation by some consumers contributes to the eventual economic benefit of all, earlier precedent in support of promotional practices should be applicable. Some States have adopted legislation specifically authorizing conservation programs, eliminating any doubt about their validity.

If rate structures that encourage conservation are valid and mandated, subsidies for use of solar energy, which employ a non-depletable, nonpolluting energy source, should also be valid. Use of solar energy is supported by the same public interest and public policy as conservation--decreased use of fossil fuels.

State antidiscrimination statutes are not the only factor to consider in discriminatory practices by utilities. The Federal antitrust laws may also outlaw rates or services that single out the owners of solar energy systems for special treatment. The longstanding antitrust exemption for State action will not totally immunize public utilities from antitrust liability.

There are several grounds on which utility rate and service discrimination toward solar users could be deemed anticompetitive, and therefore a violation of antitrust laws. A utility may be deemed a monopoly if it charges a very high price or even refuses to provide backup service to solar customers. An antitrust violation might also be found if a utility subsidizes its entrance into the solar heating and cooling market by distributing its losses across all utility customers, giving it an overwhelming advantage.

Such conduct could be viewed as temporary price-cutting to put rival solar firms out of business. Or, it might be viewed as an illegal tying arrangement in situations where a solar customer's receipt of favorable treatment is conditioned on his acceptance of the utility service.

The conference committee on the National Energy Act has, at this writing, taken steps toward resolving these rate issues, but failed to completely clarify the situation. While most of the President's proposals for dictating rate reform at the Federal level failed to gain conference approval, the conferees did allow the Federal Energy Regulatory Commission (FERC) to prescribe rules requiring electric utilities to offer to sell power to or to buy power from qualifying cogenerators or small power producers and prevent discrimination against such producers. (Small power producers in this case are facilities generating less than 80 megawatts from solid waste or renewable resources; the definition of a qualifying generator is left to the FERC.) While this provision permits Federal regulation of the relationship between utilities and small solar generating facilities, it leaves the difficult problem of determing just rates up to the FERC.

The Public Utilities Regulatory Policies Act of 1978

On November 9, 1978, Congress passed the National Energy Act (NEA), which included five separate statutes, one of which was the Public Utilities Regulatory Policies Act (PURPA). In the past, electric and natural gas utility rates were based upon a weighted average of historical costs of capital and energy. Many utilities also had declining block rate structures: each succeeding block of energy was less expensive than the preceding block. When fuels were relatively inexpensive, and additional quantities of energy to the same customer would be supplied cheaply, these rate structures accurately reflected the cost of serving consumers. However, fuel costs have increased rapidly and significantly in the interim, and conservation has been given priority.

A second difficulty created by the utility pricing techniques was that a large fraction of the housing stock was constructed based upon these artifically cheap rates. Consequently, homes were designed to use large quantities of energy for heating and air conditioning. This exacerbated peak energy requirements and made the serving of peak energy demands even more expensive.

However, utility rates did not distinguish between peak energy usage, which was more expensive to supply, and nonpeak usage, which could be served more cheaply. Thus, utility rates did not accurately reflect either the cost of service to consumers or rapidly rising energy prices.

The Public Utilities Regulatory Policies Act (PURPA) focuses upon electric and natural gas utility rate structures. Through use of regulations, PURPA requires that utility rate structures reflect the true cost of providing service to each class of consumer. Although rates may still be based upon historic costs (so that consumers will benefit from previous installations of relatively inexpensive plant capacity), utilities are required to consider rate structures which reflect the fact that peak period energy is more expensive to supply than off-peak energy. Thus, Section 111 of PURPA suggest that utilities consider seasonal and time-of-day rates. These rate structures should allow solar energy systems to compete more effectively with natural gas and electricity. Since utility rates will more accurately reflect the cost of service, potential solar energy investors can more efficiently assess the alternatives.

Section 202 of PURPA will allow for the possibility that cogenerators and small power producers may be connected to the utility. Section 210 indicates that public utilities must offer to exchange (buy and sell) energy with such interconnected systems. This reduces the uncertainty of operating a solar energy system. By being guaranteed that some form of backup--electricity or natural gas--will be supplied by a utility, and that any excess energy generated by the solar energy system will be purchased by the utility, users are provided with a more certain supply of energy.

Regulations based upon these sections will improve the efficiency of energy usage and encourage choices among energy systems that are based upon economic opportunity costs. Such regulations will reduce the uncertainty associated with ownership of a solar energy system and make other energy supply systems (electricity and natural gas) reflect costs of service more accurately.

However, there may be some equity problems associated with these regulations. When a solar energy system is connected to an electric utility, it may not sell electricity back to the utility at a price greater than the utility would have paid for power from another source (its avoided costs). But solar energy users may also be allowed to buy electricity from the utility grid at the rates that other consumers are paying. If consumption rates are based upon historical cost and selling rates are based upon avoided cost, this discrepancy could work to the advantage of the solar energy owner. While this would obbiously encourage solar energy usage, it could also mean that nonsolar energy users would be subsidizing those using solar energy.

Title IV of PURPA uses financial incentives to promote hydroelectric power projects. Loans are used to make hydroelectric projects more attractive relative to the alternatives. If solar energy systems and hydroelectric projects are complements (i.e., if solar energy systems are used to pump water up into a hydroelectric storage facility, for use at a later time) such financial assistance will improve the viability of solar systems as well as hydroelectric facilities. However, to the extent that hydropower and solar energy output are substitutes (i.e., both can be used to meet peak energy demands), then such assistance to pumped hydro will reduce the viability of solar energy systems.

Another portion of PURPA (Title VI) authorizes the development of an information program. Funds are provided to aid the National Association of Regulatory Utilities Commissioners in creating an institute that will collect, develop, and make available research on utility regulatory issues.

The Powerplant and Industrial Fuel Use Act of 1978

Another statute of the National Energy Act of 1978 was the Powerplant and Industrial Fuel Use Act (PIFUA). This statute restricts the use of petroleum and natural gas by electric utilities and major fuel-burning installations. By reducing the use of these energy systems, the act seeks to encourage utilization of domestically abundant coal and renewable energy sources. However, usage restrictions also impose costs upon utilities, industries, and their customers. Thus, while industry and utilities may be forced to seek out renewable forms of energy, the cost of such a shift may be very significant.

Ownership of Onsite Equipment

The complex rates required to encourage design of onsite equipment best suited for the energy network of which it is a part, would, of course, be obviated if utilities owned the onsite systems outright. While there clearly are disadvantages associated with expanding the monopoly position of utilities, there are a number of reasons for believing that utility ownership of onsite solar equipment may be attractive in many circumstances.

1. Utilities are uniquely able to optimize the mix of generating and storage equipment in their service area and to develop control strategies for minimizing overall utility costs; (This could, of course, also be done by a company owning only transmission and distribution equipment.)

2. Utilities compare the cost of energy derived from new solar equipment to the cost of generating energy from new electric-generating equipment or the marginal cost of gas from

new sources, while all other solar owners must compare solar costs to the lower imbedded costs of energy which determine commercial rates.

3. Utilities are probably better able to raise large amounts of capital for longterm energy investments than any other type of organization.

As the statistics in table V-4 indicate, electric utilities require several times more capital per dollar of sales than typical industrial firms (although the capital intensity has declined rapidly in recent years because of the rapid increase in fuel costs).

Table V-4 -- The Capital Intensity of Major U.S. Industries
(Dollars of plant to secure $1.00 of revenue)

		$
Investor-owned electric companies:	(1965)	4.51
	(1970)	4.39
	(1975)	3.20
	(1977, est)	2.96
Bell Telephone System (1971)		2.95
10 major railroads (1971)		2.48
Gas transmission companies (1971)		2.43
Gas distribution companies (1971)		1.62
10 major integrated oil companies (1971)		1.25
500 diversified industrial companies (1971)		0.87
50 major retailers (1971)		0.43

SOURCES: National Gas Survey, U.S. Federal Power Commission. Ebasco Services Incorporated (New York, N.Y.), 1977
Business and Economic Charts, p. 28

At the end of 1974, electric utilities owned approximately $150 billion in plants and equipment--nearly 20 percent of all business plant equipment in the United States.

An ability to raise capital for long-term investments is particularly critical for solar energy devices since solar energy is very capital-intensive and typically requires a number of years to return the initial investment.

Utilities, therefore, may be uniquely able to provide initial capital for solar devices in situations where individuals (particularly individuals in lower income groups) and organizations may find the capital requirements prohibitive.

Reserves in the stock market, uncertainties about the future of the energy industry, and difficulties in obtaining rate changes from utility commissions have, however, made it progressively more difficult for utilities to raise capital in recent years.

4. Utility capital tends to be less expensive than capital required by more speculative industries.

   A typical utility can raise 50 percent of its capital from debt--while most manufacturers rely on debt for only 10 to 15 percent of new investment capital, the remainder of the capital being purchased at higher rates from investors.

   Utility capital costs may, however, be higher than those experienced by homeowners and can be higher than the cost of capital available for financing typical residential and commercial buildings. A homeowner earning a tax-free return of 10 percent on capital invested in solar energy equipment may be well satisfied. This advantage is moot, of course, if the individual is unable to raise any capital for the project at all.

5. Utilities are already in the business of selling energy and have the required infrastructure for billing, marketing, and repairing equipment. Some potential owners of onsite devices have been wary of investing in equipment which might lead them to unfamiliar maintenance problems or the hiring of specialized personnel.

6. Utility ownership or marketing of solar equipment and a willingness to stand behind the equipment once installed could increase consumer confidence in the equipment.

There is some ambiguity, however, about whether utility ownership of small energy equipment would be permitted by Federal antitrust statutes.

Ownership of Onsite Equipment -- Ambiguity of Definition

Most State statutes define a public utility to include any person, corporation, partnership, association, or other legal entity and their various representatives. A solar facility owned by a landlord, or a private property owner, as well as any partnership or corporate entity would qualify as a public utility, if the other qualifications are met.

Where there is no sale of electric power involved, but rather the owner and user are the same legal entity, State regulations govern. Federal regulations concern only the wholesale rate for interstate electricity sales. Rarely will owner-used energy be subject to Federal regulation as a public utility. This is true whether the owner is a single family, a joint venture composed of the various users, or a corporation which supplies its own corporate needs.

Where the owner is not the sole user, State Statutes vary. The general rule is that a company which supplies energy "to the public" will be found to be a public utility, whereas a device which is not producing energy for public use will escape utility regulations. Law in this area is very unclear and the ambiguity may be a barrier to the introduction of solar equipment.

A facility can be judged to be dedicated to "public use" if its owners: (1) demonstrate a willingness to serve all who request service; (2) voluntarily submit to State regulation; (3) attempt to exercise the power of eminent domain.

Even activities which do not clearly involve a dedication to public use may be declared by the courts to be "so affected with the public interest" that utility commission jurisdiction is justified. In one recent case, the owner of a shopping center was not allowed to sell energy to stores in the shopping center without being regulated as a utility.

If an onsite solar system is found to be a public utility, it must file reports and accounts, serve all customers who demand service within a given area, submit its rate schedules to the utility commission for approval, continue providing service until given permission to discontinue, provide safe and adequate service, comply with limitations on the issuance of securities, and apply for certificates of public convenience and necessity. State utility regulatory statutes universally require that every public utility obtain a certificate before beginning operation or even construction of its equipment. Meeting these requirements would be a prohibitive burden for most potential owners of solar equipment, since the proceedings are frequently long and expensive.

Even if a solar owner were willing to undertake the trouble and expense to file as a utility, he would have to recognize that an existing utility will be able to maintain a monopoly in its geographical area unless the courts determine that public convenience and necessity require otherwise. A new utility is therefore rarely permitted in an area already served by an existing utility. Even where the existing utility is providing woefully inadequate and inefficient service, it will be permitted to exercise monopoly control over its service area if it promises to correct its shortcomings.

The initial factor in determination of whether an onsite solar system in a public utility is who owns the system? Ownership can range from the privately owned solar system on a privately owned residence, to cooperatively owned systems for a small community, to a corporate-owned collector field on corporately leased or publicly owned property, to utility-owned systems on private residences. Clearly, somewhere in the continuum of owners the onsite solar facility and its owners become subject to regulation as a public utility.

Ownership of Onsite Equipment -- Electricity, Steam or Heat?

Another factor in determining whether an onsite solar use is subject to regulation as a public utility is the form in which energy is supplied to the users -- electricity, thermal energy (steam or hot water), or chemical energy. Solar equipment may become available which will produce energy in each of these forms. Again, State statutes vary. For example, some States do not vest jurisdiction over production and sale of steam in their utility commission. State statutes vary greatly, however, and generally thermal energy is not regulated simply because there is no explicit mention of the issue in the statutes.

Still another aspect of this question is whether the sale of energy by an onsite producer subjects the owner of the onsite equipment to regulation. Sale to a presently regulated utility should be interpreted as would sale to any other category of user. Under most State statutes, sale of excess steam or electricity to a specified public utility probably would not meet the test of dedication to public use which is required in determination of public utility status. In a number of cases, industries that generate excess electricity or steam or sell it to public utility companies have been held not to be public utilities. However, in some States the opposite has resulted.

The congressional revision of the National Energy Act takes some action in exempting onsite owners from regulation, but leaves many issues unresolved. The conference agreed to exempt cogenerators and small powerplants producing up to 30 megawatts of electric power from State utility regulations (apparently granting the FERC the authority to overrule States in these issues) and exempts biomass generators smaller tha 80 megawatts from the Public Utilities Holding Act. The act would, however, apparently not permit exemptions for subsidiaries of utilities since small generators qualifying for the exemption must be owned by organizations whose primary business is not energy generation.

Ownership of Onsite Equipment -- Utilities

Previous discussions have assumed that the owner of the onsite solar system was also the owner of the land and building upon which the solar system is located. Is it permissible for utilities or other corporations to own onsite solar facilities on land which the utility does not own, such as the property of the user?

The short answer to this question seems to be yes, although antitrust laws and State policies designed to promote competition would probably prevent utilities from establishing exclusive marketing rights for solar equipment. Utilities probably would be required under existing law to compete with other distributors of solar systems.

The law is clear that utilities at least would not be barred from the solar equipment market. A recent analysis of the question of permitting gas utilities to invest in onsite conservation equipment concluded that Federal antitrust statutes would not be violated if the utility only purchased conservation devices (in this case, insulation material) from independent suppliers and did not actually manufacture or install a major share.

Exemption from Federal antitrust statutes is apparently permitted in some cases where an expansion of utility operations is undertaken at the suggestion of a State utility commission and not on a utility's initiative. Precedents exist permitting utilities both to expand their business to include activities under regulatory authority and to own subsidiaries which are not regulated.

There have been cases where, at a utility's request, an unregulated industry was placed under regulatory control. The Pacific Telephone Company, in California, for example, owned an unregulated subsidiary for a number of years which installed and operated mobile radio telephones. The company subsequently asked the California Public Utility Commission to place this activity under regulatory control. The Commission accepted the application, but a private competitor appealed the decision. The California Supreme Court upheld the Commissions approval, in a divided decision. The court found that mobile telephone service was closely related to the utility's regulated business and that the equipment, used for telephone communication, fell under the jurisdiction of the regulatory authority.

At the same time, there are cases where utilities have not been able to place subsidiaries of this type under public utility commission regulation. For example, the New York Service Commission limited the activities of utilities in solid waste disposal ventures, and AT&T was prohibited from expanding its unregulated business as a part of a settlement.

It is unclear whether an existing public utility will be permitted to own a solar system which is permanently placed on the roof or other property of a customer. Since such a system is probably a fixture, the utility would be required to leave the solar system in the home or office, even if the property is sold or leased. The most practical approach is for the utility to finance the purchase of the solar equipment and thus permit its easy disposition as a fixture, but retain the usual metering, repair, and maintenance relationships with the customer.

Nonutility corporations could also own onsite solar equipment. Probably, such a corporation would supply only equipment, and perhaps maintenance, but not energy. Under most State statutes, provision of energy equipment is not subject to utility commission jurisdiction.

The specific arrangement between the solar equipment leasing company or seller and the property owner may alter the question of utility regulation. For example, the inclusion of a service agreement between the lessor and the lessee might increase the likelihood of regulation, as would more widespread adoption of solar devices. Additionally, to the extent that such an agreement requires backup power from public utilities, the contracts and prices for these provisions would be indirectly subject to regulation as part of the normal utility rate regulation.

Congress apparently has taken a dim view of utility ownership and financing, since the committee of conference on the National Energy Act rejected the President's proposal that utilities be permitted to finance the installation of insulation and other expensive residential conservation equipment. While the conference encourages utilities to perform energy audits of residences, it prohibits utilities from installing conservation devices other than furnace-efficiency modification, clock thermostats, and load-management equipment. Loans to cover these devices are limited to $300; (State commissions are permitted to ask for an exemption from this prohibition).

The field remains quite ambiguous, however, and many possibilities remain open. It may be attractive, for example, for utilities to operate solar equipment as a part of an unregulated subisdiary. Such an arrangement would eliminate concerns, expressed by some potential owners of cogeneration equipment, that equipment on their premises, owned by a regulated utility, would not be able to sell energy on an equitable basis because of special pressure to adjust utility rates.

Ownership of Onsite Equipment -- Municipal Utilities

Since municipal utilities can finance plants with relatively low-interest, tax-free bonds, the capital costs associated with plants owned by municipals can be lower than those of plants owned by privately owned utilities. Lowering capital costs is particularly important in the case of solar energy systems where the bulk of the energy cost results from the cost of capital. In most States, however, municipal utilities are prohibited from expending funds for "private benefit" and this has been interpreted to mean that municipal utilities cannot purchase shares in generating facilities which are partly financed and operated by a private utility.

These prohibitions may also prevent municipals from owning or operating onsite generating systems. In the case of solar devices, however, it would seem that the municipals could make a strong case that installation of a solar device would benefit the public at large even though it was primarily designed to meet the energy needs of a single building. In fact, several municipal utilities have experimented with onsite solar energy equipment in their districts. The legal point may be moot since, as one analyst put it, "Who's going to complain?"

In any event, the laws preventing municipals from owning part shares in generating facilities which will be partly owned and operated by private utilities are being changed in many areas of the country to allow municipals to share the cost of constructing nuclear-generating facilities and other centralized energy equipment, which, like solar energy systems, have high capital costs. Prohibitions against such "joint action" programs are often written into State constitutions. The constitution of the State of North Carolina, for example, was recently amended by referendum to permit joint-action financing of new electric utility plants. Such amendments have been controversial in some areas. For example, in 1977, the Governor of Indiana vetoed legislation amending that State's constitution to allow joint-action programs.

Cost-Sharing Issues

If a utility were to own or operate onsite generating facilities, contracts between customers and the utility would have to address several important issues; they include:

1. Who would pay the property tax on the equipment? (This is particularly important because utility tax rates often are several times higher than those for homeowners.)
2. How would costs of insurance be distributed. Would utilities be liable for damage to onsite equipment caused by the homeowner?
3. Would a contract for onsite solar equipment be binding on a new owner if title to a building were transferred?
4. How far would a utility's maintenance responsibility extend? Would a utility, for example, be responsible for keeping a roof on which a solar collector was mounted in weatherproof condition?
5. Should a utility pay a customer for the use of a roof or wall for installing a solar collector? If so, would the fee decrease for the use of walls and roofs that did not permit optimum collection of radiation?
6. Could a customer demand that a utility remove onsite equipment? If so, who would pay for removal?

None of these questions pose insoluble problems, but all may require careful negotiation. All of the utilities interviewed by the General Electric Company said they preferred onsite facilities on large buildings, because questions would be easier to resolve than if large numbers of small buildings were involved.

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6. Wells, Malcolm and Irwin Spetgang, "Sunlight and the Law" *How to Buy Solar Heating...Without Getting Burnt!*, Rodale Press, Emmaus, Pennsylvanie, 1978, Cahpter 8.

7. "Solar Clips -- Utility Incentives", *Solar Age*, Volume 6, No. 1, January 1981, p. 14.

CODES, LEGALITIES, CONSUMERISM AND ECONOMICS

FINANCIAL ISSUES

STUDENT MATERIAL

CODES, LEGALITIES, CONSUMERISM AND ECONOMICS

FINANCIAL ISSUES

THE IMPORTANCE OF FINANCING

Introduction To Financial Issues

The Need For Credit: Regardless of the type of solar energy system being planned, the materials and labor costs for construction may require financing. The extent of the financing needed will depend on the type and size of the system. The cost of a solar energy system may vary from a minimal amount to a sizable portion of the building value. For simple passive solar energy systems such as the addition of awnings for south-facing windows, the costs may be very little. Many types of active solar systems can also cost very little. Yet, if the system is a major addition to an existing structure or a major factor in a new structure's design, the costs can be considerable.

The average buyer, even after many years of saving, will be unable to amass the necessary full purchase price of a large solar installation. The large amount of capital necessary to finance such systems in relation to the small annual income keeps ownership out of reach unless credit aid from others or from private or public lending agencies can be secured.

Money For Sale: At one time or another each of us has asked to borrow something; perhaps it's been nothing more than a garden tool from a neighbor, or a cup of milk when we've been caught short. No matter what, we probably made our loan request in a somewhat apologetic manner. We were asking a favor from someone who was in the position of granting or not granting it, and it put us in an uncomfortable position. This apologetic manner, when asking someone to favor you with a loan, usually becomes more intense when you approach a lending institution and ask for money. It shouldn't be that way. The fact is, you are not asking to borrow, but are really offering to purchase the only commodity the lending institutions have for sale. Just as the merchant sells his wares to earn a living, and the lawyer his counsel, so too, do the lending businesses sell their stock-in-trade: money.

Just as the ice cream shop cannot operate with only one can of ice cream, these lending institutions cannot make money by lending only a little. Some have many millions (and sometimes billions) of dollars available for "sale". In order to avoid failure, and perhaps bankruptcy, lenders must keep their "merchandise" moving. What they get for their funds must be greater than what they pay for their funds...or they are in trouble! Their job, then, is to lend ("sell") their available funds at a profit to qualified borrowers (what constitutes a "qualified borrower" is the subject of later discussions). Each day that the available dollars sit in the vault, unused, lenders are losing money (as interest payments to their depositors).

Lending institutions also compete with one another, just as Gulf Oil does with Exxon. When you are shopping for a new appliance, you check the price and quality everywhere--in catalogues, department stores, specialty shops, newspaper ads, etc.--to get the best return for your purchase price. You can, and should, do the same when you shop for a cash loan. Terms and interest rates are items on your shopping list to get the best "buy".

Solar Energy As Collateral: Solar energy heating and hot water systems are operating in hundreds of American homes today. They hold the promise of supply for much of the energy used in the home, which today (1976) accounts for one-fifth of total national energy consumption. But this will only come to pass if hundreds, thousands, and finally millions of individuals decide to buy or build solar-equipped housing.

Many factors will affect this process, including the price and availability of competing energy sources, improvements in the design of solar energy systems, and similar issues that will determine how soon such systems make economic as well as environmental sense. One of the most important of these factors may be the willingness of lenders to provide mortgage loans for solar housing, and in particular the terms on which financing is available. This is not so much because of what makes solar energy systems different and unusual, but rather because of what they have in common with many other aspects of housing: a large capital cost that must be financed and paid for over time.

Elements of Financing

Financing A Solar Energy System: Solar does offer advantages--it will have a significant impact on tomorrow's energy planning--so what now?

If you are a potential owner of a solar energy system:
.....you will need to decide if the system is a good investment,
.....can you afford to pay for it?

If you are a contractor:
.....you will need to decide if you can offer custom-designed systems,
.....will you be able to tailor the costs and performance to the owner's budget?

If you are a lender:
.....you will need to decide if the risk is reasonable and the value significant,
.....can you provide financing for this new energy technology?

Thus, consideration must be given to: (1) financial planning for the investment, (2) the effects of the system on cash flow and taxes, and (3) the system cost, performance, and life which can help "sell" the investment.

Consumer's Cash Flow: A solar energy system--and for that matter, any capital expenditure on a building--will have an impact on the owner's cash flow. (Cash flow for our purposes is defined as the amount of money spent each month on the building by the owner.) The repayment of the financing loan must be considered. And the effect the investment may have on monthly energy costs, personal or business taxes, and property taxes must be considered. The borrower must consider making a loan that is reasonable and within the personal or business budget requirements. The right balance of system performance and cost must be made according to the individual's financial capabilities.

Property taxes are those on real-estate (for the most part). If the assessed value of the solar system is $2000 and the property tax rate is 2%, the increased property taxes would generate a negative cash flow of $40 per year or $3.33 per month.

Personal or business taxes are those on income. The income tax savings generated are a function of the owner's tax bracket and the size of the loan. An individual in the 25% tax bracket paying $300 per year in interest could generate $75 annual income tax savings.

Of course, the added property taxes could result in some additional income tax savings. Additional tax credits and property-assessment exclusions for solar systems are either already available or are the subject of legislative action both at the state and federal level.

It has long been recognized that the market for housing is extremely sensitive to financing terms. Interest rate, length of payment period, and amount financed directly determine the monthly payment that housing owners will make to finance solar energy installations. The size of this monthly payment (and the downpayment) will significantly affect the economics of solar energy sytems from the owner's perspective. Table 1 is a checklsit designed to help the borrower in making a loan decision.

TABLE 1 -- REAL-ESTATE-LOAN CHECKLIST

1. Does a consumer loan or a mortgage loan best serve my needs for this size debt?

2. Can I borrow against my current mortgage, or is it necessary to obtain a new loan, refinancing the property?

3. If I have to refinance, what will my total interest bill become considering the outstanding balance on my old debt?

4. What type of real estate loan best suits my needs?

5. What are the current rates of interest at the different types of lending institutions in my particular area?

6. Do I have the details of the "extra costs", such as appraisal fees, points, loan application fees, taxes, preparation of legal instruments, etc.?

7. Will refinancing change my tax appraisal or otherwise affect my tax assessment?

8. Am I eligible for a FHA or VA insured loan and can I obtain it at less cost?

9. How large a down payment will I have to make? Will a larger down payment decrease the interest rate?

10. Are there any prepayment penalitites if I need to move before the term of the loan expires?

11. How are late charges handled?

12. Do I have to deposit taxes, insurance, etc., in escrow and do they earn interest?

13. Am I required to provide any additional security such as a compensating balance in savings or securities or a note on other property?

14. Does the mortgage contain a "due-on-encumberance clause" preventing me from using my equity in the property as security for other short term loans I might need to make?

15. Is disability and life insurance available? Is it optional or required? How do the rates compare to term insurance?

16. Can the loan be assigned or sold to another lending institution? Can they change the terms without prior approval?

17. What is the local reputation of the lending institution with other borrowers? How well do they service their customers?

18. Have I shopped well for my loan and obtained the best loan available in terms of rates, length, and general terms?

Lender's Monetary Policy and Interest Rates: The most dominant financial institution in the United States is the Federal Reserve Banking System, often termed "the Fed". The Fed, to a large extent, manages the nation's money supply, which directly affects private financial institutions, such as commercial banks, savings and loan associations, and mutual savings banks. A number of other public and quasi-public agencies have been established specifically to buy and sell mortgages, and to promote certain housing policies. These institutions and agencies financially tie construction and real estate activity to the national economy.

The president, the Treasury Department, and the Federal Reserve System work together to achieve the economic goals of the country. The main goals are full employment, economic growth, and price stability. It is apparent that one of the major ways to achieve the first two goals is to have an adequate supply of money in the economic system. Too much money in the system, however, can result in inflation. Too much money puts more purchasing power (demand) in the system than can be satisfied by the available goods and services (supply) at existing price levels. The excess purchasing power competes for the available goods and services, pulling prices upward. This of course is not consistent with the third goal, price stability. Adjustments in the money supply (monetary policy) are thus made to provide an acceptable balance in the goals.

Like other goods, the price of money, i.e., interest rate, varies in response to supply and demand conditions. For example, if the money supply is cut back or tightened, interest rates go up. Alternatively, if unemployment and recession are national problems, one solution is to increase the money supply. With increased supply, funds begin to build up in financial institutions which must be lent out if interest is to be earned. The interest is lowered and more business and individuals can afford the price. Thus, interest rates or mortgage loans must go up or down according to monetary policy in effect at the time.

The availability of money and the level of interest rates greatly affect lending or borrowing terms. As money gets tighter, lenders raise interest rates; they may also shorten the term or life of loans made. The result can be a substantial debt service (i.e., the periodic payment on a loan for interest and principal repayment). For example, suppose tighter money conditions cause a lender to raise the interest rate from 8 to 10% and decrease the life from 30 to 25 years. On a $30,000 mortgage, these changes would increase monthly debt service from $220.14 to $272.61, as may be seen from the following table:

LIFE (Years)	INTEREST RATE			
	4%	6%	8%	10%
15	$221.91	$253.17	$286.71	$322.38
20	181.77	214.92	250.95	289.50
25	158.34	193.29	231.54	272.61
30	143.22	179.88	220.14	263.25
35	132.81	171.06	213.09	257.88

What does this mean to a borrower? Assume a typical family can apply 15% of its annual income to mortgage debt service. With the changes mentioned above, the income of a family able to borrow $30,000 on a mortgage loan would increase from $17,611 to $21,809, a difference of $4,198. An increase of this amount would obviously sharply reduce the number of buyers able to meet the demands of a $30,000 mortgage. This would be true at all income levels, and if sustained, would reduce the number of units demanded and would eventually result in across-the-board reduction in the quality of products for the population.

Normally financial institutions need a 1½ percent buffer or differential between the interest rate they pay on savings deposited with them and the interest rate they charge on mortgage loans. However, mortgage loans are long-term commitments at fixed terms. The interest rate paid on deposit tends to go up periodically with increasing rates in the economy. The result is a squeeze on profits.

For example, assume savings and loan association assets in mortgage loans and cash as follows: 30% in mortgage loans made over ten years ago at an average rate of interest of 6%, 30 percent made five to nine years ago at 7½%, and 30% made in the last five years at 9% rate of interest, the balance, or 10% of the assets are held in cash and in buildings and equipment that earn 0 income. The interst rate on savings account deposits is to be increased from 5.0 to 5.5%. What effect is there on the overall profit margin?

30% x 6 % ------------ 1.80%
30% x 7½% ------------ 2.25
30% x 9 % ------------ 2.70
10% x 0 % ------------ 0.00

Weighted rate of return-----6.75%

Before the increased rate on deposits, the margin or differential equaled 1.75% (6.75% - 5.0%); after, the differential dropped to 1.25% (6.75% - 5.5%), not enough to cover operating costs and leave a profit, since the institution needs a 1½% differential. Thus, lenders must be cautious when running the risk of being locked in on a long-term, fixed interest rate mortgage.

Types of Residential Loans

Borrowing For Residential Purposes: There are three basic ways of obtaining funds for residential purposes. These are (1) home improvement loans, (2) second mortgage loans, and (3) first mortgage loans. Cost-wise, first mortgage loans are normally less expensive than home improvement loans, which are usually less expensive than second mortgage loans. The following table compares the relative cost of the three types.

HOW FINANCING AFFECTS SOLAR COSTS

Illustrative Loan Terms and Monthly Debt Service
Under Private Lender Financing Alternatives

	LOAN TYPE							
	FIRST MORTGAGE					SECOND MORT-GAGE	HOME IMPROVE-MENT	
	Conventional			FHA	VA	Con-ventional	Title I	Con-ventional
Loan/Value Ratio	70%	80%	90%	93%	100%	75%	100%	100%
Interest Rate	8.5%	8.75%	9.0%	8.25%	9.0%	13.5%	11.5%	12.5%
Maturity (years)	27	27	27	30	30	10	12	5
Mortgage Insurance	—	.15%	.25%	.5%	—	—	.5%	—
Monthly Cost per $1,000 of Loan	$7.88	$8.16	$8.41	$8.06	$8.23	$15.23	$13.13	$22.50

Source: HUD-PDR-218, Home Mortgage Lending and Solar Energy, published March 1977.

Home Improvement Loans: To finance the installation of a solar system on an existing residence, the owner could (1) remortgage the residence, (2) obtain a home improvement loan, or (3) take on a second mortgage.

Remortgaging, although an option, is generally unwise since the rate of the existing home mortgage is probably lower than that of any new mortgage that could be obtained. The monthly cost at first appears lower since the loan would be paid back over a long-term period (25 to 30 years), but the overall cost would make this an expensive approach for any solar retrofit financing.

The most common solution is the home improvment loan which covers a variety of lending arrangements offered by every kind of lending institution. The conventional home improvement loan is generally available from savings and loan associations, savings banks, commercial banks, credit unions, and even private finance companies. The cost ranges anywhere from about 12.5% a year upwards. Generally, it is limited to a five-year maturity, so monthly payments are higher than they might be with a longer-life mortgage loan. A Title I home improvement loan refers to home modernization loans made under Title I of the Federal Housing Act. Its significance lies in the fact that its maturity can extend for as much as twelve years, thereby greatly reducing the monthly payment. Its cost, at about 11.5% (mid 1977), is also slightly less than that of the conventional home improvement loan.

At a slightly higher cost (from 1 to 2 %) than that of the conventional home improvement loan, is the second mortgage. As with a first mortgage, the residence is the security and monthly payments consisting of principal, interest and other charges are made in addition to the first mortgage payments. Since the holder of the first mortgage gets paid first, the second mortgagee's claim is riskier and naturally carries a higher interest rate and service fee. Also, even if the borrower pays off his first mortgage, should he default on his second, the holder of the second mortgage has the right to foreclosure. Aside from this risk, a second mortgage means paying out two substantial installments every month, for a long period of time--the payback period can extend to ten years.

New Homes: A first mortgage is the most desirable way of financing a totally new, solar-heated residence. Depending on the amount of downpayment the borrower can afford, several types of first mortgages are available for the new home loan.

For relatively low-income farm families, there is the FmHA (Farmer's Home Loan Agency). An FmHA loan has many restrictions, but is by far the least expensive (the loans are sometimes as low as 1 to 2%) and it requires little by way of down payment. If a family of four has an income of $5000 or less (mid 1977), there is a possibility of obtaining this type of financing.

VA (Veteran's Administration) guaranteed loans also require minimal down payment and cost much less than home improvement loans or second mortgages. The VA does not actually make the loan; it only guarantees to the lender that if the borrower fails to make payments, the VA will assume the obligation. The borrower is confronted with a two-step task: getting VA approval for the loan and finding a lending institution that will make the loan under the VA guidelines.

FHA (Federal Housing Administration) loans require the borrower to have at least 7% of the loan as downpayment. The FHA (and VA also) require borrowers to certify that they hold no secondary mortgages or promissory notes before they can be approved for a mortgage. The FHA only insures the loan and the borrower is confronted with the same two-step task noted above for VA approval.

Conventional mortgages require greater down payments, generally at least 20% of the cost of the new residence ($10,000 on a $50,000 purchase), but here there is a truly competitive market where shopping can save the borrower many dollars. Also, the borrower has a variety of first mortgage types to consider. The most familiar types are:

> The direct-reduction, fully-amortized, loan--the one most commonly used. Equal payments are made over the life of the loan and the entire sum is paid at the end of the loan period. As each monthly payment is made, it is first credited to the interest on the outstanding balance and then any sum remaining is used to reduce the outstanding debt.
>
> The limited-reduction-plan, partially-amortized loan, commonly known as the "baloon" mortgage. This mortgage is generally written for a shorter term, and the unamortized balance is paid in a lump sum at the end of the loan period.
>
> The straight-reduction, fully-amortized loan, where a specified amount is paid on the principal plus the inter on the outstanding balance. The payment becomes smaller as the debt is reduced.
>
> Mortgages are also written open-ended where additional money can be borrowed against the same mortgage. Such borrowing is usually limited to the amount of principal repaid.

Qualifying The Borrower

Elements of Qualification: The first step in the lending process is the filing of an application by a prospective borrower A typical Application For Credit is shown in Figure 2. At this point, the lender should obtain information from the borrower as to the amount of the loan required, the rate of interest desired, the proposed terms of repayment, and the purpose for which the loan is secured. Should the borrower require a lower rate of interest than the institution's policy permits, no further time need be spent in processing the loan application. The same would be true with respect to the requirements of the borrower as to amorization or term. The question of use of the loan is important. It is one thing if the borrower wants the loan to pay part of the purchase price of a piece of property that he or she intends to put to some sound use, or to repair or rehabilitate property, or to refinance existing debts against the property. It is quite another if he or she desires to raise money on owned property for some highly speculative enterprise that may bring about financial downfall.

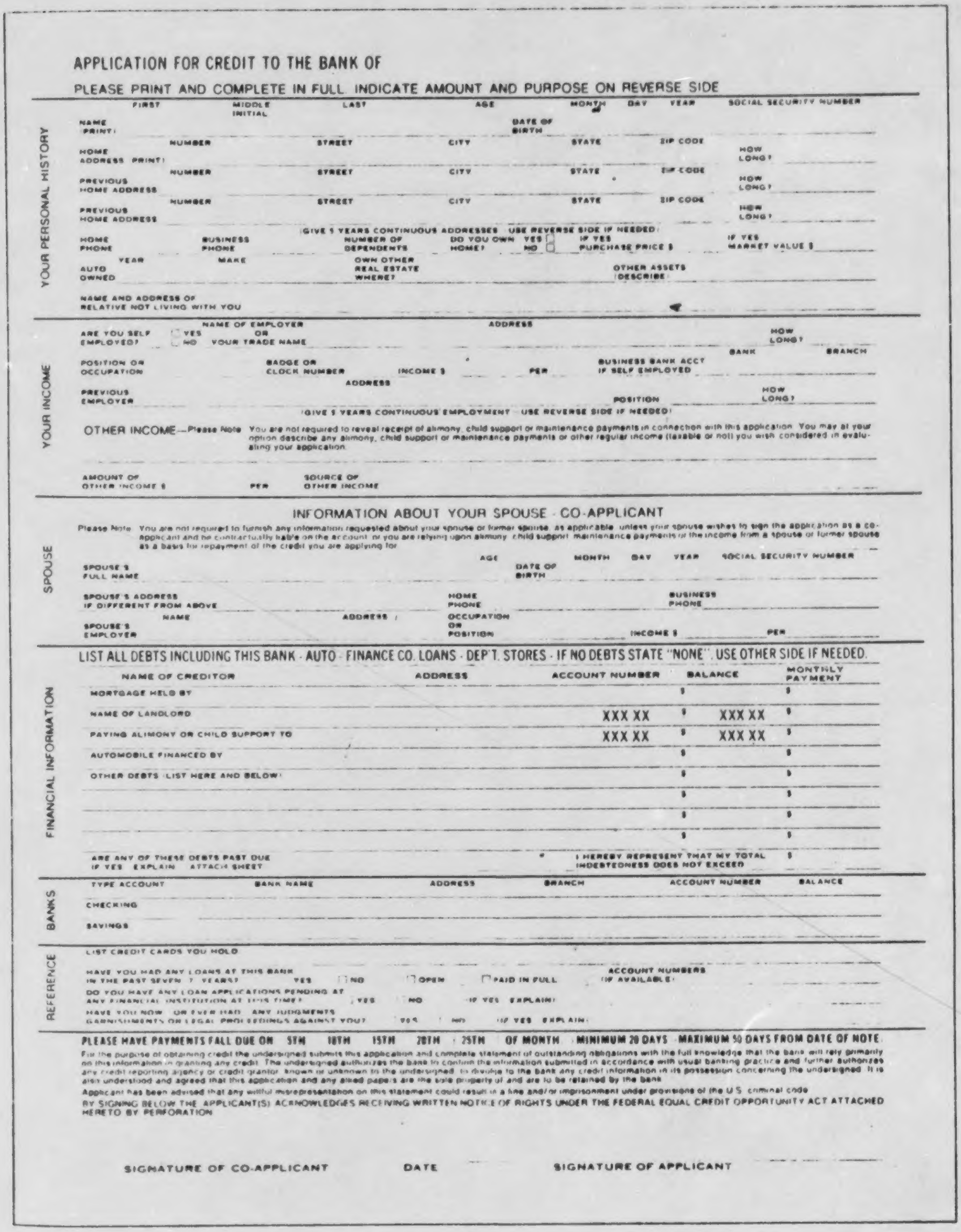
The lender should obtain information also as to the financial means of the prospective borrower, including his or her occupation and income, assets, and existing financial obligations.

The lender should then proceed to appraise carefully the property offered as security and the financial ability of the borrower. It would not be sound business policy to take the borrower's statement of his or her means at its face value. Certainly, the lender would not, without inspection and appraisal, take the borrower's word about ownership of an excellent building at a given location that was in a certain state of physical repair and that produced an income of a given amount. Hence, a credit investigation is made either by the lender or by one of the many credit agencies that operate for this purpose.

Having inspected the property and determined its value, and having weighed and established the financial capacity of the borrower, the lender is then in a position to determine how much can be safely advanced and upon what terms it can be advanced. It is unlikely, with respect to any loan, that the highest standards of the lender will be met from the standpoint of all the factors involved. It may be that the borrower's circumstances are excellent and that the property is a good one, but that there is some likelihood of neighborhood decline beyond average.

This being the case, the lender may decide to require a more rapid rate of amortization. In another case it may be found that although the borrower's credit is not as strong as it might be, the property iteslf and its surroundings are beyond average, or the desired amount of loan is sufficiently low to offset this particular weakness.

Figure 2(a)



APPLICATION FOR CREDIT TO THE BANK OF

PLEASE PRINT AND COMPLETE IN FULL. INDICATE AMOUNT AND PURPOSE ON REVERSE SIDE

YOUR PERSONAL HISTORY

NAME (PRINT) FIRST MIDDLE INITIAL LAST AGE DATE OF BIRTH MONTH DAY YEAR SOCIAL SECURITY NUMBER
HOME ADDRESS (PRINT) NUMBER STREET CITY STATE ZIP CODE HOW LONG?
PREVIOUS HOME ADDRESS NUMBER STREET CITY STATE ZIP CODE HOW LONG?
PREVIOUS HOME ADDRESS NUMBER STREET CITY STATE ZIP CODE HOW LONG?
(GIVE 5 YEARS CONTINUOUS ADDRESSES. USE REVERSE SIDE IF NEEDED)
HOME PHONE BUSINESS PHONE NUMBER OF DEPENDENTS DO YOU OWN HOME? YES ☐ NO ☐ IF YES PURCHASE PRICE $ IF YES MARKET VALUE $
AUTO OWNED YEAR MAKE OWN OTHER REAL ESTATE WHERE? OTHER ASSETS (DESCRIBE)
NAME AND ADDRESS OF RELATIVE NOT LIVING WITH YOU

YOUR INCOME

ARE YOU SELF EMPLOYED? ☐ YES ☐ NO NAME OF EMPLOYER OR YOUR TRADE NAME ADDRESS HOW LONG?
POSITION OR OCCUPATION BADGE OR CLOCK NUMBER INCOME $ PER BUSINESS BANK ACCT IF SELF EMPLOYED BANK BRANCH
PREVIOUS EMPLOYER ADDRESS POSITION HOW LONG?
(GIVE 5 YEARS CONTINUOUS EMPLOYMENT. USE REVERSE SIDE IF NEEDED)

OTHER INCOME—Please Note: You are not required to reveal receipt of alimony, child support or maintenance payments in connection with this application. You may at your option describe any alimony, child support or maintenance payments or other regular income (taxable or not) you wish considered in evaluating your application.

AMOUNT OF OTHER INCOME $ PER SOURCE OF OTHER INCOME

SPOUSE

INFORMATION ABOUT YOUR SPOUSE · CO-APPLICANT

Please Note: You are not required to furnish any information requested about your spouse or former spouse, as applicable, unless your spouse wishes to sign the application as a co-applicant and be contractually liable on the account, or you are relying upon alimony, child support, maintenance payments or the income from a spouse or former spouse as a basis for repayment of the credit you are applying for.

SPOUSE'S FULL NAME AGE DATE OF BIRTH MONTH DAY YEAR SOCIAL SECURITY NUMBER
SPOUSE'S ADDRESS IF DIFFERENT FROM ABOVE HOME PHONE BUSINESS PHONE
SPOUSE'S EMPLOYER NAME ADDRESS OCCUPATION OR POSITION INCOME $ PER

FINANCIAL INFORMATION

LIST ALL DEBTS INCLUDING THIS BANK · AUTO · FINANCE CO. LOANS · DEP'T. STORES · IF NO DEBTS STATE "NONE". USE OTHER SIDE IF NEEDED.

NAME OF CREDITOR	ADDRESS	ACCOUNT NUMBER	BALANCE	MONTHLY PAYMENT
MORTGAGE HELD BY			$	$
NAME OF LANDLORD		XXX XX	$ XXX XX	$
PAYING ALIMONY OR CHILD SUPPORT TO		XXX XX	$ XXX XX	$
AUTOMOBILE FINANCED BY			$	$
OTHER DEBTS (LIST HERE AND BELOW)			$	$
			$	$
			$	$
			$	$

ARE ANY OF THESE DEBTS PAST DUE IF YES EXPLAIN (ATTACH SHEET) I HEREBY REPRESENT THAT MY TOTAL INDEBTEDNESS DOES NOT EXCEED $

BANKS

TYPE ACCOUNT	BANK NAME	ADDRESS	BRANCH	ACCOUNT NUMBER	BALANCE
CHECKING					
SAVINGS					

REFERENCE

LIST CREDIT CARDS YOU HOLD
HAVE YOU HAD ANY LOANS AT THIS BANK IN THE PAST SEVEN (7) YEARS? ☐ YES ☐ NO ☐ OPEN ☐ PAID IN FULL ACCOUNT NUMBERS (IF AVAILABLE)
DO YOU HAVE ANY LOAN APPLICATIONS PENDING AT ANY FINANCIAL INSTITUTION AT THIS TIME? ☐ YES ☐ NO (IF YES, EXPLAIN)
HAVE YOU NOW (OR EVER HAD) ANY JUDGMENTS, GARNISHMENTS OR LEGAL PROCEEDINGS AGAINST YOU? ☐ YES ☐ NO (IF YES, EXPLAIN)

PLEASE HAVE PAYMENTS FALL DUE ON 5TH 10TH 15TH 20TH 25TH OF MONTH (MINIMUM 20 DAYS, MAXIMUM 50 DAYS FROM DATE OF NOTE)

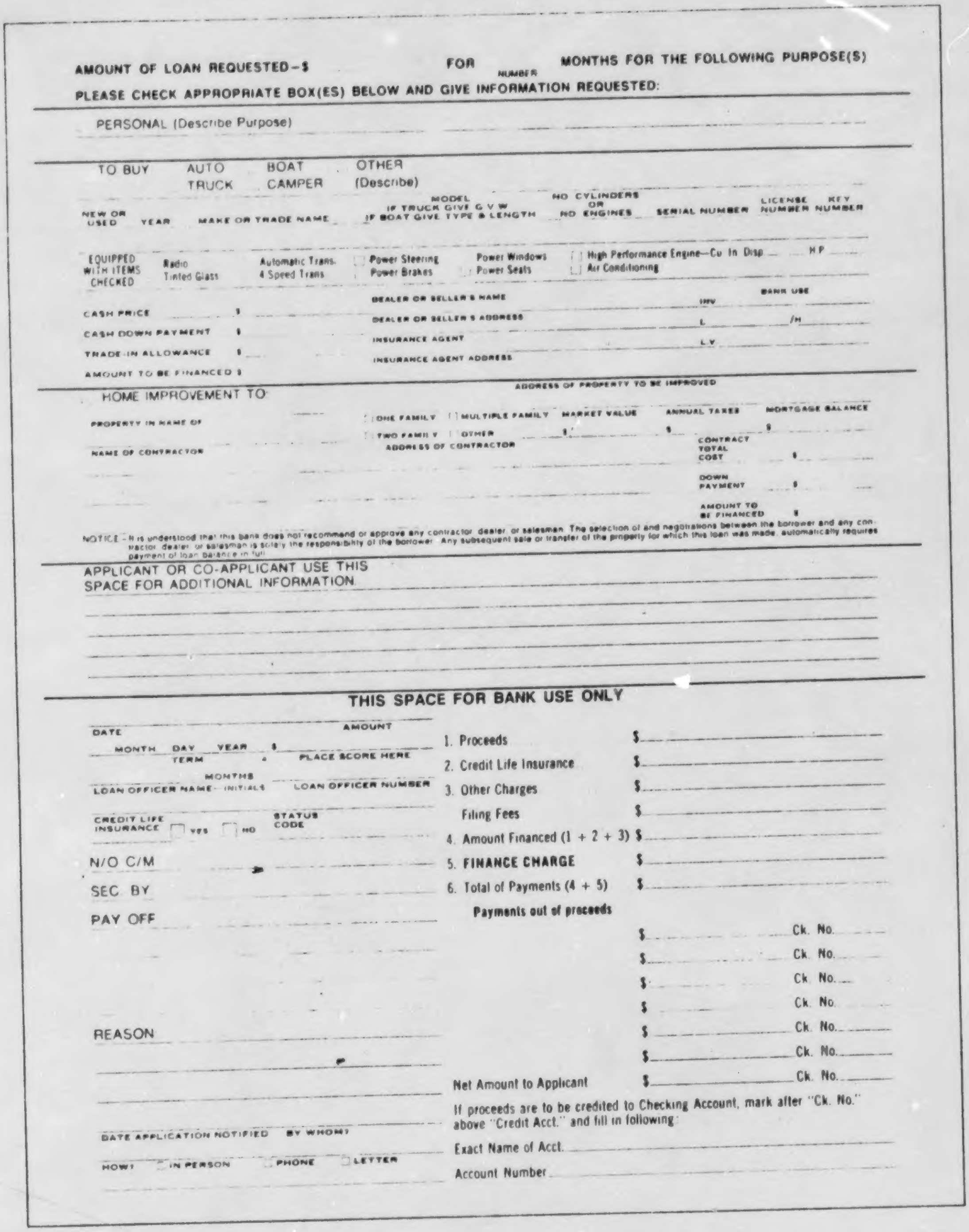
For the purpose of obtaining credit the undersigned submits this application and complete statement of outstanding obligations with the full knowledge that the bank will rely primarily on this information in granting any credit. The undersigned authorizes the bank to confirm the information submitted in accordance with usual banking practice and further authorizes any credit reporting agency or credit grantor, known or unknown to the undersigned, to divulge to the bank any credit information in its possession concerning the undersigned. It is also understood and agreed that this application and any allied papers are the sole property of and are to be retained by the bank.

Applicant has been advised that any willful misrepresentation on this statement could result in a fine and/or imprisonment under provisions of the U.S. criminal code.

BY SIGNING BELOW THE APPLICANT(S) ACKNOWLEDGES RECEIVING WRITTEN NOTICE OF RIGHTS UNDER THE FEDERAL EQUAL CREDIT OPPORTUNITY ACT ATTACHED HERETO BY PERFORATION

SIGNATURE OF CO-APPLICANT DATE SIGNATURE OF APPLICANT

Figure 2(b)



AMOUNT OF LOAN REQUESTED—$ FOR NUMBER MONTHS FOR THE FOLLOWING PURPOSE(S)

PLEASE CHECK APPROPRIATE BOX(ES) BELOW AND GIVE INFORMATION REQUESTED:

PERSONAL (Describe Purpose)

TO BUY AUTO TRUCK BOAT CAMPER OTHER (Describe)

NEW OR USED	YEAR	MAKE OR TRADE NAME	MODEL IF TRUCK GIVE G V W IF BOAT GIVE TYPE & LENGTH	NO CYLINDERS OR NO ENGINES	SERIAL NUMBER	LICENSE NUMBER	KEY NUMBER

EQUIPPED WITH ITEMS CHECKED
Radio
Tinted Glass
Automatic Trans.
4 Speed Trans
☐ Power Steering
Power Brakes
Power Windows
☐ Power Seats
☐ High Performance Engine—Cu In Disp H P
☐ Air Conditioning

CASH PRICE $
CASH DOWN PAYMENT $
TRADE-IN ALLOWANCE $
AMOUNT TO BE FINANCED $

DEALER OR SELLER'S NAME
DEALER OR SELLER'S ADDRESS
INSURANCE AGENT
INSURANCE AGENT ADDRESS

BANK USE
INV
L /H
L V

HOME IMPROVEMENT TO:
ADDRESS OF PROPERTY TO BE IMPROVED
PROPERTY IN NAME OF
☐ ONE FAMILY ☐ MULTIPLE FAMILY
☐ TWO FAMILY ☐ OTHER
MARKET VALUE $
ANNUAL TAXES $
MORTGAGE BALANCE $
NAME OF CONTRACTOR
ADDRESS OF CONTRACTOR
CONTRACT TOTAL COST $
DOWN PAYMENT $
AMOUNT TO BE FINANCED $

NOTICE – It is understood that this bank does not recommend or approve any contractor, dealer, or salesman. The selection of and negotiations between the borrower and any contractor, dealer, or salesman is solely the responsibility of the borrower. Any subsequent sale or transfer of the property for which this loan was made, automatically requires payment of loan balance in full.

APPLICANT OR CO-APPLICANT USE THIS SPACE FOR ADDITIONAL INFORMATION

THIS SPACE FOR BANK USE ONLY

DATE MONTH DAY YEAR
AMOUNT $
TERM MONTHS
PLACE SCORE HERE
LOAN OFFICER NAME - INITIALS
LOAN OFFICER NUMBER
CREDIT LIFE INSURANCE ☐ YES ☐ NO
STATUS CODE
N/O C/M
SEC. BY
PAY OFF
REASON
DATE APPLICATION NOTIFIED
BY WHOM?
HOW? ☐ IN PERSON ☐ PHONE ☐ LETTER

1. Proceeds $
2. Credit Life Insurance $
3. Other Charges $
Filing Fees $
4. Amount Financed (1 + 2 + 3) $
5. **FINANCE CHARGE** $
6. Total of Payments (4 + 5) $

Payments out of proceeds

$ Ck. No.
$ Ck. No.
$ Ck. No.
$ Ck. No.
$ Ck. No.
$ Ck. No.
Net Amount to Applicant $ Ck. No.

If proceeds are to be credited to Checking Account, mark after "Ck. No." above "Credit Acct." and fill in following:

Exact Name of Acct.
Account Number

Borrower's Ability To Repay: Information obtained from the borrower's loan application should include the financial means of the prospective borrower, including his or her occupation and income, age, existing financial obligations, and assets, including bank accounts, stocks and bonds, and so forth. This information enables the lender to determine the financial ability of the borrower and his or her worth as a bondsman. It is not profitable for lenders to have to foreclose mortgages to get back the money they lend. Profitable mortgage investment requires the repayment of interest and amortization on a regular basis over the term of the loan. If a buyer is financially weak, there is danger that he or she will not be able to meet these requirements. The question of the borrower's credit is therefore very important.

Insured/Guaranteed Provisions: Where the borrower desires to use mortgage terms authorized under FHA-insured or VA-guaranteed loan provisions, and the lender is able and willing to make the loan under the specified terms and rates of interest, special application forms provided by the federal agencies must be submitted, together with required filing fees for independent check and loan approval by the FHA or VA, whichever is involved. Both agencies make detailed and careful field checks, applying ratings to all the physical property, the site, the location, the ability of the mortgagor to shoulder the financial obligation, and the mortgage pattern wherein all factors bearing on the quality of the loan are correlated. Based on the results of the agency's investigation, the institutional lender is authorized to process or reject the loan application. If the former, the maximum amount of the loan, the interest rate, and the loan period subject to which the federal agency commits itself to insure or guarantee the loan are considered. Should the amount of the loan and loan terms that the lending institution is able or authorized to offer be acceptable, the next step involves sending advance disclosure of closing costs and of truth-in-lending information to the buyer-borrower.

Qualifying The Collateral

Elements of Appraisal Qualifications: If the mortgage appears acceptable to the lender on the basis of the credit application, that person must then proceed to appraise carefully the property offered as security. For our purposes here, it is sufficient to say that great care must be exercised in determining the worth of the physical security as well as the future of the neighborhood in which it is located. An owner may have an excellent building in a neighborhood that has a very poor future outlook. The condition of surrounding properties and the trend of an area can adversely affect a given property even though it is excellent itself.

Cost-Life-Performance: Most solar energy systems for actively heating structures are a major investment for a building owner. As such, they need to be financed and paid for out of fuel savings and regular income. The bank that invests in an active solar energy system needs to know that it's investment is protected if the investor is for some reason unable to meet his commitment to repay the loan. The building owner should be prepared to answer questions relating to system performance, cost, and life for the banker. Investment in solar systems is new. The average lending institution has not had ample experience in assessing the solar system investment.

The cost of an active solar system will vary over a very wide range depending on what it is expected to do. Systems costing from $5000 to $15,000 are not unusual. Solar system life and maintenance has to be determined. (These factors are discussed in relation to life-cycle cost analysis.) Depending on how well the system is designed and installed, a 5 to 25 year life without major maintenance can be expected. Solar system performance can be predicted by techniques of sizing and design. A square foot of solar panel, depending on the location and the type of system, will give from 100,000 to 300,000 Btu per year of solar heat.

The lending institution may require to see the solar system plans. However, the best way to proceed appears to be for the owner to obtain an estimate for a typical system first. And, then, talk with the lender concerning the feasibility of any loan for solar. The lender can then request specific additional information from the building owner and possibly, from the consultant or contractor.

Property Value: The building owner should also be prepared to answer questions relating to the system's effect on real-estate values for the lender. Life, aesthetics, and performance of a solar system will have a marked effect on the real-estate value of a building structure. A system designed to last more than 20 years, which enhances or does not detract from the appearance of the structure, and has an acceptable cost-life-performance value will grow in value rather than depreciate. As fuel costs rise, the structure will become more and more desirable on the real-estate market.

FINANCIAL INSTITUTIONS

Sources of Capital

The Borrower's Options: Although the cost of a residential solar energy system may be large or small, the borrower's choices for financing are limited by the residential purpose for the loan. In the case of an addition to an existing structure, the solar energy system may be financed as a home improvement using short-term consumer loans. A new structure, on the other hand, will entail long-term mortgage loan financing.

Short-Term Loans: For amounts under $5000, the borrower will normally look for a short-term, consumer, loan. This type of loan is available from credit unions and commercial banks. Some financing may also be available from finance companies or through retail installment credit plans. Interest rates from finance companies and credit plans are usually much higher than those from credit unions and banks.

Mortgage Loans: There are many types of real-estate mortgage loans which are generally made by savings and loan institutions, commercial banks, mutual savings banks, life insurance companies, and mortgage companies. However, the mortgage market would be far smaller in size and considerably different in structure and functioning than it is today in the absence of the public support for home mortgage financing that has evolved over the past forty years. At the present time, a diverse array of Federal mortgage insurance programs, interest subsidies, secondary market support operations, and banking and income tax regulations combine to establish the context within which institutions provide residential mortgage loans. In particular, two classes of public institutions--Federal credit agencies and secondary market entities--may have a marked influence on the availability of financing for solar homes.

Short-Term Loan Financing

Credit Unions: Credit unions are nonprofit institutions, usually operated by a church or a business, so their interest rates tend to be lower than commercial banks. Members of credit unions save by purchasing shares in the association. Out of the accumulated savings fund, loans are made to its members. The law permits unsecured loans up to $750 and adequately secured loans in larger amounts, depending on the size of the credit union. Repayments are made periodically, according to an agreed-upon schedule, but they may not extend over more than five years. A credit committee elected by the members of the credit union passes upon the applications for loans.

Finance Companies: Obtaining financing through finance companies is generally easier than through a commercial bank. Finance companies are businesses established for serving consumer credit needs. In return for speed and lack of intensive questioning, the borrower will pay a high interest rate. The reputable loan company operates under state license, which gives varying degrees of protection to the borrower. And since the passage of the Truth-In-Lending Act, loan sharking has become a federal offense. But this does not mean that a loan shark cannot still attempt to operate and the borrower should first check on the company's reputation through the local Better Business Bureau. In general, solar installation financing through the small-loan company should not be employed unless funds cannot be obtained from a lower-rate source.

Retail Credit Plans: Many companies set up "easy payment" plans. The customer pays a presettled amount each month until the specific merchandise is paid for. The time periods of installent contracts will vary and the carrying charges also. Interest charges mount up during a spread-out paying period. Advertising such as "Easy terms! No down payment, three years to pay" may involve a prolonged and inflated debt for the borrower. For example, a service charge of 1½% per month is typically used for such plans; that's 18% per year!

Mortgage Loan Financing

Broadly speaking, mortgage markets are classified as primary markets and secondary markets. The primary market is made up of lenders who supply funds directly to borrowers, bear the risks associated with long-term financing, and who, as a rule, hold the mortgage until the debt obligation is discharged. The secondary market is composed of lenders who seek an outlet (employment) for their funds, but who are neither equipped nor willing to originate or service the mortgage debt. These lenders merely buy mortgages as long-term or temporary investments in competition with other types of securities, such as government or corporate bonds. Agencies that purchase mortgages for resale or lend against them are also active in the secondary market. Primary and secondary market operations are not as clear-cut as the above explanation would lead one to believe. Many lenders act in a dual capacity, as primary lenders to the limit of their own funds for investment, and also as originators, service agents, and assignors of mortgages for which they find a profitable demand in the secondary mortgage market.

Nearly all direct mortgage financing is supplied by private lenders and the sources for credit are many. Each source has its peculiarities which may be caused by state or federal laws, or by internal organizational rules of the lending institutions which forbid mortgage lending in excess of certain amounts or in certain geographical areas. Private sources of credit are supplied by three principal lending groups: individual lenders, institutional lenders, and mortgage companies (also termed mortgage bankers).

Individual Lenders: Individual Lenders account for less than one-ninth of the total mortgage debt, yet they are important as a source of prime mortgage funds and are by far the largest source for junior mortgage loans. Funds supplied by individual lenders include those loaned by trustees of indivudual trusts, estates, endowment, pensions, or corporate funds and those made available by fraternal and similar nonprofit organizations that seek investment outlets for their surplus funds.

As a rule, the individual lender cannot compete with the institutions in securing prime mortgage loans. Because of the benefits arising from large-scale operations, institutions can supply funds at lower costs and hence lower interest rates than those that the individual can afford to offer. It is true that the lending requirements of the institutions are more stringent than those that govern the individual. Institutions, on the other hand, are less apt to be compelled to take advantage of a borrower's adverse condition during times of economic stress.

Institutional Lenders: Increasing interest by state and federal agencies in home construction and liberalization of home mortgage lending policies have sparked institutional lenders to assume a leading role in home mortgage financing. The institutions whose lending practices and policies exert the greatest influence on the mortgage market include the following:

1. "Thrift institutions" (as savings and loan associations, mutual savings banks, and similar institutions are commonly designated).

2. Commercial banks.

3. Life insurance companies.

Thrift institutions--savings and loan associations and mutual savings banks--accounted for nearly half of the debt in 1974, and their share is increasing. Figures 18-1 and 18-2 show the relative importance of lenders based on the amount of outstanding loans and lending by property type. These institutional lenders deal directly with the borrower, and provide him with construction funds and mortgage credit. And their policies and practices largely determine the reception accorded any new type of housing innovation (i.e., solar energy installations or designs) on its first being introduced into the primary mortgage market.

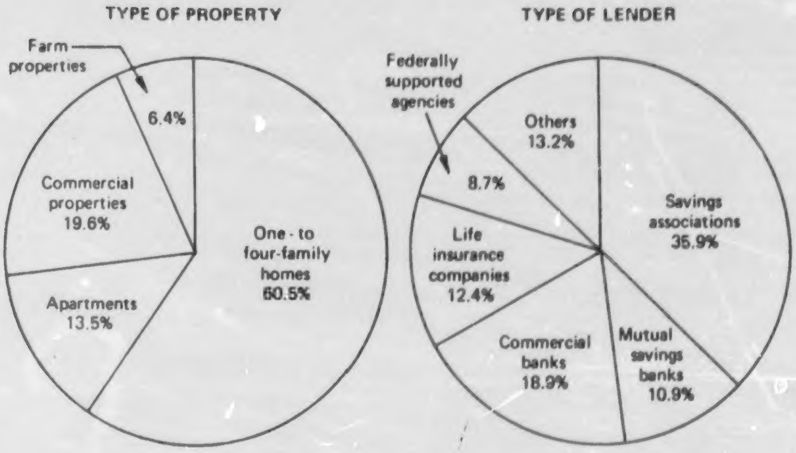


Figure 18-1. Total Mortgage Loans Outstanding, Year-End 1974.

Thrift Institutions: Thrift institutions have been in the business of channeling personal savings into residential loans for more than one hundred years, and are the dominant private institutions in the residential mortgage market today. More than 5500 of these institutions provide over half of all permanent loans for single-family homes and nearly one third of those for multi-family structures. Since savings deposits have been less subject to withdrawal than other kinds of banking accounts, the "thrifts" have been well suited for making long term mortgage investments. Although they also represent the major source of construction funds for single-family homes, their primary motive for making short-term credit available is to be in a position to write the permanent mortgage later.

Savings and Loan Associations: Among institutional lenders, savings and loan associations account for nearly one-half of the home loan mortgage market. Although savings and loan associations have been active for over one hundred years, regulations that govern their loan activities on a regional and national scale did not go into effect until 1932 when Congress created the Federal Home Loan Bank System. Today all federally chartered savings and loan associations, and most state-chartered associations that can qualify, are members of the Federal Home Loan Bank System and subject to its supervision. Membership in the Federal Home Loan Bank System permits borrowing by the association from a district home loan bank whenever funds are needed to pay off the share accounts of withdrawing members or to finance additional mortgage loans.

Most savings and loan associations, if qualified, have joined the Federal Savings and Loan Insurance Corporation (authorized by Congress in 1934), under which membership deposits are federally insured up to $40,000. This insurance, together with uniform lending policy and accounting supervision, has greatly increased public confidence in savings and loan institutions and brought about a considerable increase in their total assets and outstanding mortgage loans.

Federal Home Loan Bank System regulations provide that member savings and loan associations may make conventional installment loans up to 95 percent of the lesser of appraised value or purchase price of the home offered as security, with a maximum loan of $42,000. Alternatively, at 90 percent of value or price, a conventional home loan may be made up to $55,000. The loans must be amortized on a monthly basis with a maximum term of thirty years. The loans must be secured by first-mortgage liens on residences within the state of the association's home office or within one hundred miles of the home office if outside the home office state. First-mortgage loans may be made in excess of $55,000 provided the loan-to-value ratio is less than 80 percent. Second-mortgage loans and construction loans are permissible but must have much shorter terms to maturity.

FHA and VA loans may be made up to any loan-to-value limit acceptable to the Federal Housing Administration or the Veterans Administration.

Savings and loan associations' lending powers are subject to limits imposed by the Federal Home Loan Bank System. The main purpose of the limits is to balance risks in the portfolios of associations. This risk balancing generally takes the form of a maximum proportion of an association's assets that may be invested in any one type of loan or venture. The main lending activities, and the limits that apply, are as follows.

Purchases of participation shares in conventional mortgage loans may be made from "approved" lenders outside an association's lending area. Approved lenders include insured banks, savings and loan associations, government secondary mortgage market agencies, and other FHA-approved mortgagees. The participation share in any one out-of-area mortgage must not exceed 50 percent and the aggregate of all out-of-area participation shares must not exceed 20 percent of the association's assets. Participation makes possible the channeling of funds from localities of low housing and mortgage demand to localities of high demand.

First-mortgage loans may also be made on business and income properties, churches, and other improved properties up to a maximum loan-to-value ratio of 75 percent. A maximum term of twenty-five years is required along with monthly loan amortization payments. No more than 20 percent of an association's assets may be placed in "business property" loans.

Savings and loan associations may, in addition, make real property improvement, alteration, repair, and equipment loans. The aggregate amount of such loans may not exceed 20 percent of an association's assets. The maximum term of such loans is fifteen years, thirty-two days, and monthly amortization payments are required. Equipping loans are limited to $5000 per property.

Mutual Savings Banks: Mutual savings banks are dedicated to accepting and protecting the savings of individuals and to channeling these savings into productive investments, primarily real estate. That is, mutual savings banks act as financial intermediaries. About two-thirds of the savings are invested in real estate mortgage loans.

All mutual savings banks are chartered by states. And most mutual savings banks are located in the Middle Atlantic and New England States, with nearly seven-eighths in the states of New York, Massachusetts, Connecticut, Pennsylvania, and New Jersey. Over 90 percent of the total deposits are concentrated in these five states, with New York accounting for over one-half of the total. Mutual savings banks tend to dominate where savings and loan associations are weak, and vice-versa. Effectively this means that both function as financial intermediaries for long-term savings.

As mentioned, mutual savings banks are state-charted only, and, except for Delaware and Maryland, must invest their monies in home states and adjoining states. These lending restrictions do not apply, however, in regard to purchase of FHA-insured or VA-guaranteed mortgage loans.

The mortgage lending limits of mutual savings banks are as follows. In most states the law restricts real estate loans to 65 or 70 percent of the assets of any bank. Some states exempt FHA and VA loans from this restriction. Also, FHA and VA loans may be made up to any loan-to-value ratio of 95 percent. And conventional, uninsured loans may generally be made to 80 percent, and occasionally to 90 percent, of appraised value, with an amortization period of thirty years.

Commercial Banks: Commercial banks are required by law to maintain greater relative liquidity in their assets than other financial institutions to meet possible withdrawal requests of depositors. Thus, although commercial banks control the largest percentage of U.S. savings (nearly half), their role in mortgage lending continues to be, for them, a secondary activity. Making commercial short-term loans to local business firms is their primary activity. Short-term loans enable the banks to maximize profits and at the same time meet their liquidity requirements.

The mortgage lending policies of commercial banks depend on the size of the banks' operations and on the community's financial needs. National banks, and most state banks, cannot make loans in excess of 75 percent of their time or savings deposits, or 100 percent of their combined capital and surplus, whichever is greater. Government- or state-insured or guaranteed loans are exempt from these ratio limitations.

Conventional uninsured loans may be made up to 80 percent of the appraised value and may extend to thirty years, if fully amortized over the loan period. Insured conventional loans may be made to 95 percent of value with a term of thirty years, if fully amortized. FHA-insured and VA-guaranteed loans may be made to any loan-to-value limits with terms allowed by the federal government. Commercial banks may also make leasehold loans of more than ten years and construction loans of up to twenty-four months.

Commercial banks generally increase mortgage lending activity when demand for local business loans is slack, and decrease mortgage lending when business loan demand is strong. That is, they tend to invest funds in mortgage loans only when funds on hand exceed local business needs. The improvement in secondary mortgage market operations has lessened the pressure on commercial banks to avoid heavy mortgage lending. With an active secondary mortgage market, mortgages can be sold off by a bank to increase its cash on hand; thus mortgages are not reasonably liquid as an asset.

Life Insurance Companies: Before 1965, life insurance companies ranked next to savings and loan associations in importance in lending on one-family residences. Since 1965, and undoubtedly because of continued and deep inroads of inflation and the resultant erosion of the purchasing power of the dollar, insurance companies have steadily, if not wholly in some instances, withdrawn from mortgage lending on individual residences. Life Insurance companies are currently interested not only in exacting the maximum possible interest return on their mortgage loans but also in seeking a part of the equity (action) returns and especialy that share of increasing gross or net income due to inflationary causes. In the overall field of mortgage financing, including multifamily residential structures, life insurance companies rank third among the institutional lenders. The long-term nature of life insurance company assets, and the ability of actuaries to forecast the dollar amounts required in cash annually, make real estate mortgages, particularly amortizing mortgages, ideally suited as an investment medium for life insurance company funds.

Most of the larger insurance companies conduct their mortgage loan operations on a national scale. Some of the insurance companies have tied their mortgage loans to life insurance plans (at low interest charges), but most others seek mortgage loan investments as an outlet for surplus funds at interest rates averaging 9 to 10 percent. These loans are made either through branch insurance offices located in the various states or through loan correspondent brokers who process the loan applications and generally service these mortgage loans at a rate averaging three-eighths of 1 percent of the mortgage debt balance. Relaxation of state insurance company regulations, which permit a greater number of insurance companies to invest in out-of-state securities, allows insurance companies to play an important role in secondary mortgage market operations also. Insurance companies generally lend up to two-thirds of the appraised value of the property and over periods not exceeding thirty years, provided loans are amortized. FHA and VA mortgages are accepted at government-regulated loan-to-value ratios and at the legal rate of interest where such prove profitable to the lending companies.

Mortgage Companies: The liberalization of investment laws permitting insurance companies and banks in one state to acquire mortgage loans made in other states (particularly if such mortgages are FHA-insured or VA-guaranteed) created a need for financial middlemen who would initiate mortgage loans and service them for the investing companies. Many real estate firms found their related business operations well suited to fill this financial brokerage service and entered the mortgage lending field as independent mortgage companies or as loan correspondents for life insurance firms, banks, or other institutional investors. These mortgage companies are also often termed mortgage bankers.

In many states, the operations of mortgage firms has reached sizable proportions, especially in areas of the South and West where dependence on out-of-state funds is greatest. The principal role of these lenders is to provide funds for brief loan periods only. Assignment records indicate that the mortgages initiated by these brokerage firms are sold directly within a month or two to buyers in the secondary market.

Mortgage companies generally retain the right to sercive the mortgages that they initiate. A servicing fee of three-eighths of 1 percent of the outstanding debt balances is generally paid by the investment purchaser to the servicing firm. Thus, an outstanding mortgage balance of $10,000 yields $37.50 per annum, and this sum must cover not only the ledger and filing costs but also the mailing of monthly statements, follow-up correspondence, costs due to delinquent payments, and general overhead and office management expenses. Only by servicing a great volume of mortgages can mortgage loan service operations prove profitable. This need for volume results in competition for large "blocks" of mortgages in newly created subdivisions by those who combine the mortgage brokerage and mortgage servicing operations.

Probably the most dominant policy of these mortgage companies is to deal in mortgages that are most readily salable in the secondary market. As a result, these "temporary" lenders prefer government-insured or government-guaranteed mortgages and conventional or uninsured mortgages for which they have advance purchase commitments. Generally, mortgage companies restrict their conventional loans to selected residential and business risks, and to loans in price ranges most suitable to the needs of investment firms that comprise the secondary mortgage market.

Federal Credit Agencies

What Are Federal Credit Agencies?: The Federal Housing Administration (FHA), now part of the U.S. Department of Housing and Urban Development (HUD), was established to insure conventional mortgage loans made by private lenders. Its early successes were instrumental in demonstrating the soundness of the long-term, self-amortizing mortgage--today the commonly accepted credit instrument used to finance home purchases. Insurance programs modeled on FHA's were subsequently established for ex-servicemen under the auspices of the Veteran's Administration, and rural families under the Farmer's Home Administration.

FHA-Insured Mortgage: The Federal Housing Administration was created in 1934 by Act of Congress to encourage the construction and ownership of homes, especially those in the lower price ranges. Under this act, borrowers may obtain loans up to 97 percent of the value of newly constructed low-value homes that meet the requirements of the administrator. These loans on residential properties may be made on terms up to forty years. The **FHA** does not lend money. It insures loans made according to its regulations by approved lenders. For such insurance, the borrower pays a premium of 0.5 percent per annum on average debt balances outstanding during the year. Since its inception, the FHA mortgage has proved highly advantageous to both the borrower and the lender. Millions of people who might otherwise never have owned their homes have been enabled to do so on a basis that has proved very sound. The favorable interest rates and long term for repayment enable people of moderate incomes to acquire desirable homes within their means on a basis that assures freedom from mortgage debt within a definite period of time. Specifically, under the Federal Housing Act as amended, individuals are able to borrow up to 97 percent of the value of proposed or existing homes approved for mortgage lending purposes by the regional office of the FHA. These mortgage loans cannot exceed 97 percent of the first $25,000 of appraised value plus 90 percent of the next $10,000, and 80 percent of the excess over $35,000. A maximum mortgage loan is specified for one-family dwellings, two- and three-family dwellings, and for four-family dwellings.

The rate of interest plus 0.5 percent of the average annual outstanding loan to cover mortgage insurance premiums is part of the FHA regulation. FHA maximum loan and percentage ratios are subject to change by administrative and congressional action.

The requirements of the FHA as to construction and location of the property are high and are based upon very sound principles. In addition to the liberal terms obtainable by the borrower, he also has assurance that the construction of his home has met the minimum standards of experts. This is a very important feature, and it safeguards the interests of the home buyer. FHA mortgage financing is obtainable through most lending institutions. To obtain such a loan, the prospective borrower must file his application with an eligible institution. The institution then deals with the FHA, making the transaction a simple one insofar as the borrower is concerned. Should the required mortgage be on proposed construction, the borrower must furnish complete plans and specifications. The lending institution supplies the FHA with complete data, and the loan is then considered from the standpoint of physical security as well as the borrower's ability. Should it be found acceptable in all respects, a commitment is issued by the FHA which enables the lender to bring the transaction to a conclusion.

VA-Guaranteed Mortgage: Under the Servicemen's Readjustment Act of 1944, as amended, the "Korea" GI Bill of July 1952, and the Veterans Housing Act of 1974, eligible vererans and unremarried widows of veterans who died in the service or from service-connected causes may obtain guaranteed loans for the purchase or construction of a home. Although the Veterans Administration (VA) administers the provisions of the act, it does not, as a rule, lend any money. (Since July 19, 1950, and subject to periodic congressional renewal, the VA has been authorized to make direct loans to veterans in areas where private capital at approved rates of interest for VA home financing is not available. These direct loans are limited to a maximum amount, although the amount may be increased in high-cost areas.) As in FHA-insured mortgages, the loans are made by banks and other qualified mortgage lenders. The VA merely guarantees the payment of a part of the loan and pays the lender any loss sustained, in case of default, up to the amount of the guarantee.

The maximum guaranty credit for any one veteran is 60 percent of a loan on the reasonable value of a veteran's home, with a top quarnatee set by the existing law. This guarantee need not be used immediately or in any single transaction. Termination dates set for application of VA mortgage loans have been eliminated under the Veterans Housing Act of 1970. This new law further reinstates and extends indefinitely all unused VA entitlement of World War II or Korean conflict veterans. For veterans who served after January 31, 1955, the 1970 act extends "until used" unexpired and not yet accured entitlement. Provisions of this law are also applicable to purchase of mobile homes, condominiums, and cooperatives, as well as one-family residences.

The VA loans can be written for terms up to forty years, and the interest rate may not exceed legal limits set by the VA. No special mortgage forms are required other than thoseused in the state in which the property is situated. The mortgage, however, must provide that the veteran shall have the privilege of repaying the indebtedness in whole or in part without payment of a penalty. To be eligible for a VA guaranteed loan, a veteran borrower must have had at least ninety (90) days of active service during the official war periods or have been disabled in the service during the war. The veteran must also have been discharged under conditions other than dishonorable. Only improvements that meet VA minimum construction standards are subject to mortgage loan guaranty.

Secondary Institutions

What Are Secondary Institutions?: Originally the secondary market consisted primarily of institutional investors who sought to purchase mortgages as investments, but were not organized to make residential loans directly to borrowers. On occasion, primary lenders also act as secondary purchasers; when their supply of funds exceed the local demand for mortgage loans, they may choose to acquire mortgages from banks or mortgage companies located in other housing markets.

In recent years the secondary market has increasingly come to be identified with three government-supported agencies whose function is to join the primary mortgage market to the nation's larger capital markets in order to provide local banks with liquidity and assure a steadier supply of credit for the homebuilding industry. These three entities are:

1. The Government National Mortgage Association (GNMA), organized primarily to provide a secondary market for loans written under the Federal government's subsidized interest rate programs. GNMA is Federally owned, and operates within the Department of Housing and Urban Development.

2. The Federal National Mortgage Association (FNMA), whose mortgage purchase programs feed money into local housing markets when capital is in short supply. FNMA (since it was spun off from the Department of Housing and Urban Development in 1968) is a privately owned, but Federally regulated and supported stock corporation.

3. The Federal Home Loan Mortgage Corporation (FHLMC), organized to enable savings institutions participating in the Federal Home Loan Bank system to maintain their mortgage loan portfolios on a more liquid footing. FHLMC is a privately owned, but Federally regulated and supported stock corporation.

In recent years, FHA's mortgage insurance programs have experienced increased competition from private mortgage insurers (PMI's). Learning from FHA's experience, the PMI's have been able to offer lenders faster service without the limits on interest rates and loan amounts inherent in government insurance programs.

Federal National Mortgage Association (FNMA, FHLMC): The federal government began efforts to create a secondary mortgage market in 1935. The efforts were not particularly successful though, and in 1938 the Federal National Mortgage Association, better known as FNMA (Fannie Mae), was created.

Although the circumstances surrounding the origin of FNMA might indicate an intent to establish a permanent secondary market, it is clear in retrospect that the agency was organized as an emergency measure, the objective being to provide liquidity for government-insured mortgage loans insured at high loan-to-value ratios and at relatively low rates of interest. The association in effect was to provide money for the stimulation of new construction by purchasing mortgage obligations insured up to 100 percent of loan value by another government agency. Thus the government was to occupy the dual position of insurer and lender. FNMA operated on this basis for thirty years, responding from time to time to economic or political changes and occasionally drawing criticism.

To partially meet criticisms, but principally to provide stimulus for the lagging housing industry, the Federal National Mortgage Association, under the Housing Act of 1968, was partitioned into separate and distinct corporations. One corporation continues to be called the Federal National Mortgage Association (Fannie Mae) but is now operated as a private corporation whose stock is privately held, although operations are regulated by the secretary of the Department of Housing and Urban Development. To broaden FNMA's secondary mortgage market operations, especially in the private (conventional) sector of mortgage lending, Congress, under the 1970 Housing Act which President Nixon signed into law on July 24, 1970, provided the mechanism for a secondary market in "conventional" mortgages. The Emergency Home Finance Act in 1970 also allows the Federal Home Loan Bank Board (FHLBB) to buy and sell both government-backed and conventional mortgages. For this purpose the FHLBB has created a separate corporation, the Federal Home Loan Mortgage Corporation (FHLMC), to operate its secondary mortgage market. Aims and procedures that will guide the operations of these government-backed secondary mortgage markets are as follows:

1. Development of standardized mortgage deed of trust and note forms that will be operative in most states.

2. Encouragement of legislation to change archaic usury and other statutes that hinder mortgage lending and impede the free flow of mortgage funds among states.

3. Conventional mortgages will be purchased in approved minimum and maximum amounts under a free market auction similar to, but conducted separately from, auctionsheld for purchase of government-backed (FHA and VA) mortgages.

4. The conventional auction will be conducted by telephone. To qualify, mortgage sellers will be required by FNMA to pay a participation or offering fee of one one-hundredth of 1 percent of the amount of the offer. The fee will be nonrefundable. The seller will also be required, upon acceptance of the offer, to pay a nonrefundable commitment fee (good for a six-month commitment period) in the amount of three-quarters of 1 percent of the commitment amount.

5. Upon acceptance of the offer the seller must subscribe to FNMA common stock in an amount equal to a specified percentage, generally one-half of 1 percent. Upon delivery of the mortgages the seller must subscribe for an additional amount of common stock equal to one-half of 1 percent of the remaining balances of such mortgages. Servicers of FNMA mortgages, unless specifically authorized otherwise, must at all times offer sufficient shares of FNMA common stock equal to a specified percentage (currently 1 percent) of the total of the unpaid balances on all of the mortgages being serviced for FNMA.

6. The selling price of conventional mortgage loans will be adjusted to realize a given yield under the Free Market System auction. If the specified mortgage rate of interest is at or above the yield, the mortgage will be purchased at par; otherwise the purcahse price will be adjusted downward to produce the bid yield and on the basis of a thirty-year mortgage to be paid off in twelve years regardless of actual terms of the loan.

7. As with FHA and VA mortgages, the conventional loans must be made to mortgagors and on properties that meet standardized credit, construction, and location standards.

8. Mortgages (conventional as well as government-backed loans) are intended to be held by FNMA until amortized as scheduled, thus providing a supply of new money for the home industry in addition and above the amounts that are normally generted from traditional (private) sources.

9. FNMA is authorized to buy mortgages up to a twenty-five to one debt to capital ratio. To succeed as investor-owned secondary market corporations, FNMA and FHLMC must earn an overall yield on outstanding capital that will provide a profitable return to its capital investors.

Government National Mortgage Association (GNMA): On the division of the FNMA in 1968, into two parts, the second part became known as the Government National Mortgage Association, or, for short, Ginnie Mae. GNMA as a government agency is a division of the Department of Housing and Urban Development. It is a corporation without capital stock, designed to handle special assistance, management, and related financial functions. Special assistance functions include making financing available for selected residential mortgages in underdeveloped areas and in stablizing mortgage lending and home-building activity. The management functions of GNMA relate to its mortgage portfolio acquired from FNMA before 1968. GNMA may buy, service, and sell mortgages in an orderly manner to have a minimum adverse effect upon the residential mortgage market and a minimum loss to the federal government. GNMA and FNMA will also work "in tandem" for the purchase of mortgages for lower-income families. Under these working arrangements GNMA can commit itself to low-yield mortgages--at par--and then sell these mortgages to FNMA at the current market rate with GNMA absorbing the price differential. GNMA's securities, which are backed by pools of FHA and VA mortgages, are underwritten, of course, by the full faith and credit of the United States government.

Farmers Home Loan Agency (FmHA): The Farmers Home Administration is an office of the U.S. Department of Agriculture. Congress established the agency in 1946 to help provide loans for farmers who cannot get credit from any other source. The agency gives loans only to farmers who operate small farms, or who wish to purchase farms worth less than the average small farm in their area. Local offices of the Administration issue the loans for short periods or up to 40 years. They provide loans on the recommendations of local three-man committees which include at least two farmers. Farmers receive loans for many purposes, including farm operations and supplies, family living needs, purchase of land or housing, improvements, and special disaster relief.

Private Mortgage Insurance Companies (PMI's): A mortgage that is not FHA-insured or VA-guarnateed is generally referred to as a conventional mortgage. Such mortgages are, as a rule, made at lower loan-to-value ratios than those that are government-insured or guaranteed. To make conventional loans more competitive with high loan-to-value financing authorized under government-sponsored mortgage programs, a new concept in home financing was introduced and placed into operation in February, 1957 by the Mortgage Guaranty Insurance Corporation of Milwaukee, Wisconsin. Under provisions of this insured lending program, home purchasers can obtain conventional mortgage loans up to 95 percent of the lower of sales price or appraised property value, at going (prevailing) rates of interest and at insurance costs less than half those charged under the FHA mortgage lending system. Under federal savings and loan regulations, loans in excess of 80 percent of value cannot be offered without additional security as guarantee of debt payment in case of default. Under Mortgage Guaranty Insurance Corporation (MGIC) provisions a guarantee of the top 20 percent of the requested loan is offered which enables the savings and loan association to lend the full mortgage at costs as follows:

1. A one-time insurance charge of 2 percent of the loan value, to be paid at time of mortgage closing, or

2. An initial charge of one-half of 1 percent of the mortgage loan at time of closing, plus an appraisal fee and then one-fourth of 1 percent annually of remaining mortgage balances. The insurance may be canceled at any time by the lender. The annual charges are accrued monthly together with regular principal and interest payments.

In consideration of either of the above payments, MGIC guarantees, at its option, either to take possession of a foreclosed property and pay the insured mortgagee the outstanding debt, including defaulted interest and foreclosure costs, or to pay 20 percent of this amount without taking possession of the property.

In looking at the mortgages offered to it for insurance, MGIC considers both the property and the mortgagor but tends to place more emphasis on the latter. It insures first mortgages on one- to four-family homes, and currently about 99 percent of those were owner-occupied at the time of insurance. Except for a special program that is used only rarely, the maximum loan is limited to 95 percent of market value and is limited in amount by state or federal rules controlling mortgage lending institutions.

Although it insures mortgages on older homes, MGIC requires especially careful appraisal of both the home and the neighborhood and may require modernization of facilities within the house. Special practices apply to other types of property whose value may drop sharply.

Because of its recognition of the essential role of credit reporting in determination of risk, MGIC has established a program to improve the quality of such reports and thus lower the level of risk undertaken by both itself and its approved lending institutions. In checking on a mortgagor, MGIC pays particular attention not only to the level and stability of his income and to his housing cost-income ratio, which should not exceed 25 percent, but also to other long-term commitments for monthly payments, which should not exceed 33 to 35 percent of income in total.

The Milwaukee-based mortgage guaranty insurance company has successfully served since 1962 as the private enterprise counterpart of the FHA insured loan program. Thirteen thousand mortgage lending firms thorughout the country are currently authorized to originate MGIC-insured loans. Under terms of the private insurance program, institutions can now lend in excess of legally permited loan amounts up to 95 percent of appraised home value. The excess loan amount is insured against loss caused by loan delinquency and subsequent foreclosure at public auction.

FINANCIAL INSTITUTIONS AND SOLAR ENERGY FINANCING

Lender Awareness and Receptivity

The fourfold increase in crude oil prices following the 1973-1974 oil embargo led to price increases in all energy sources and set the stage for the growing interest in solar and other alternative energy systems. Lenders are no less aware of these critical changes than the rest of us. More than three-fourths of lenders responding (to interviews in 1976) said that energy costs have increased as a factor in their own residential financing decisions since energy costs began to rise in 1973. Virtually all believed that the impact of energy costs would continue, and the majority believed it would increase in the next five years.

This growing sensitivity of lenders to energy costs is paralleled by an increasing awareness of the solar alternative, and accompanied by a surprising optimism as to the rate at which it will become a reality.

Most lenders interviewed knew of the existence of residential solar energy heating systems, and some had a good idea of how such systems work. About one-fourth had already seen estimates of energy savings, cost-benefit analyses, or specific plans, models or installed systems. Several commercial banks had among their business customers small solar equipment manufacturers or architectural firms involved in solar projects. One savings bank surveyed was in the process of developing a new solar-heated branch office, and several other institutions are already utilizing solar energy for space heating or hot water purposes.

As should be expected, the most informed lenders tend to be those who have dealt with actual loan requests. Even here, however, the amount of information gathered on technical and even economic aspects of solar heating frequently reflects a personal interest bank officers have in the subject, rather than any analytic requirements of the loan decision. In fact, there are many issues that may weigh more heavily in the balance than detailed analyses of this sort--such as lenders assessment of when and if such systems will be commercially available in their own areas as an option for the average homeowner. Lenders appear to have a very positive outlook on the future of residential solar energy in this context. Of the lenders surveyed (in 1976) who were prepared to express an opinion, more than one-fourth thought that systems would be commercially available in their own areas within five years, and half thought this would happen within five to ten years.

Lender optimism on the prospects for the solar alternative is accompanied by a widespread belief that it is in the public interest and warrants public support. In fact, more than three-fourths of lenders questioned believed that there was a "high priority" need for the development of solar or other alternative energy sources. An even larger proportion supported an active government role in the development and dissemination of solar energy systems. And, nearly three-fourths were in favor of financial subsidies, at least in the short run, if they proved necessary.

Lenders And Solar Energy Financing

Lender Concerns -- An Overview: A positive lender attitude towards solar energy systems will undoubtedly be welcomed by the growing ranks of solar advocates. Figure 2 compiles the results of a survey of lenders (1977 data) regarding potential impacts to solar energy development as viewed by the financial sector. Lenders have already proven themselves receiptive to financing requests to some degree.

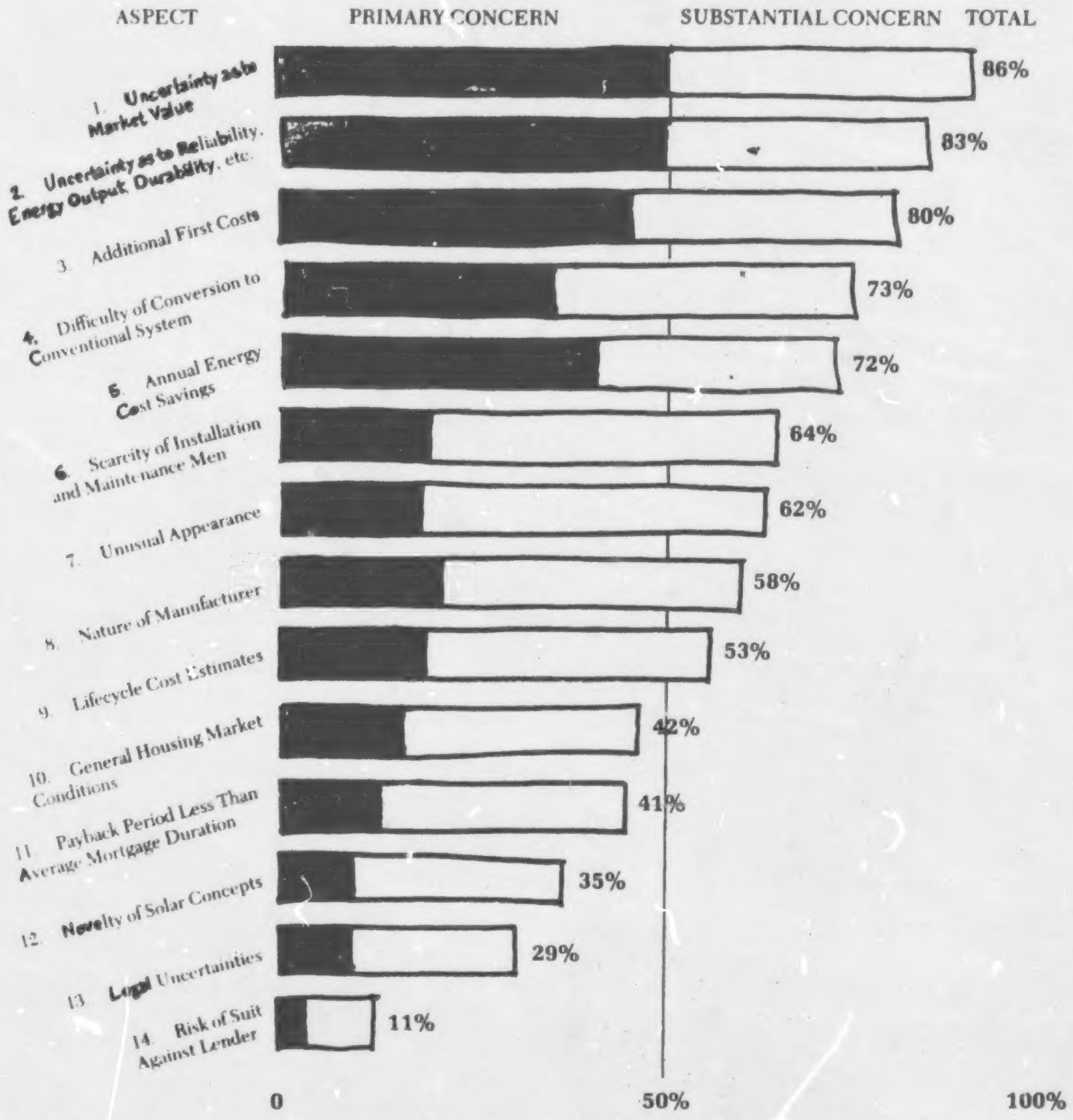
In fact, virtually all lenders surveyed believed that they would seriously consider financing requests at that time. More than a dozen New England lenders had already been approached, and loans had been made in half of these cases. And Florida lenders surveyed had been making loans on homes with solar hot water systems for over thirty years.

At this time, it should be recognized that lender support for the development of solar in the national interest, and even optimism as to its probable rate of development, is not synonymous with the unrestricted availability of financing for solar homes today. Whatever lenders attitudes on public issues may be, they must make loan decisions in a manner that accords with their day to day standards of business operations, and the standards of the numerous public regulatory agencies concerned with a sound banking system and protection of depositors interests. Those who favor residential uses of solar energy will have to understand and respond to legitimate concerns involved if the inclination of lenders to support solar is to result in the actual availability of financing. In this context, four areas of current uncertainty deserve the greatest attention:

1. Solar Retrofits;
2. The impact on property values;
3. Technical performance of the systems; and
4. Estimates of future savings in energy costs.

ISSUES OF CONCERN TO LENDERS IN MAKING LOANS

Percentage of Lenders Identifying Selected Aspects of Solar Energy Heating Systems as Primary or Substantial Concerns in Future Lending Decisions



Source: The survey conducted in early 1976 by Regional and Urban Planning Implementation, Inc., with support from the National Science Foundations.

Lender Concerns -- Solar Retrofits: In reviewing requests for consumer or home improvement loans, the lender is principally concerned with borrower credit worthiness and relatively disinterested in the value of the property as collateral for the loan. Thus homeowners planning solar retrofit installations should be able to secure financing at normal terms from traditional sources.

In terms of lender receptivity, substantially different considerations apply to retrofit installations (whether for hot water or space heating or cooling) as opposed to solar systems installed in new residentail construction. A homeowner wishing to convert an existing unit to solar hot water or solar space heat (or to make any other type of physical improvements to his home) would ordinarily apply for a "home improvement" loan.

In many and perhaps most cases, the experimental status of solar heating and hot water technologies will not affect the availability or basic terms of home improvement loans for retrofit installation. As a practical matter, it is generally expected, at least in the short term, that the vast majority of solar retrofit installation will be for hot water alone rather than for space heating. In the case of unsecured consumer loans (the likely type of financing for retrofit solar hot water), the lender's only concern is the credit worthiness of the borrower--in other words, the amount of additional indebtedness he can reasonably be expected to support. Even where the loan is secured by the "chattel" being purchased, lenders are to an increasing degree concerned primarily with the borrower, and are relatively indifferent to the purpose of the loan itself. Moreover, those seeking financing for solar retrofits will be homeowners and will frequently have a more than adequate equity built up to serve as collateral for banks that require such security.

Insofar as lenders will take the trouble to review the proposed solar retrofit system itself, their intent will be to assure that the borrower obtains a reputable product, properly installed--not to assess the attractiveness of the expenditure from an investment point of view. Here the lender is motivated by his experience that dissatisfied or defrauded consumers may be more likely to default on a loan, or in some instances, may attempt to hold the lending institution liable for the defective product. Problems could arise, however, where a first mortgage holder's permission is required and he perceives a solar space heating retrofit as potentially injurious to his security interest in the property.

Lender Concerns -- Property Value: The focus on value is inherent in the position of lenders in relation to any property on which they make loans and should be understood by those seeking financing for solar homes. Lenders in fact have a number of concrete and reasonably predictable concerns regarding the performance and economics of residential solar energy systems that must be addressed in any effort to obtain financing. It interests the lender primarily insofar as it affects the value of the property involved and the ease with which the home can be disposed of under foreclosure conditions. The controlling factors here are that mortgage loans are made in relation to the value of the property offered as collateral, rather than its cost--and that there is considerable uncertainty right now as to how much value a solar energy system adds to housing.

Performance Failure: The uncertainty of performance is essentially a particular form of lender concern over value (and related to it, of the likelihood of default). In other words, performance failure is a contingency that might require expenditures for repair or replacement by the owner-borrow, potentially jeopordizing his financial reliability and reducing the market value of the property unless and until such action was taken.

Overimprovements: What lenders will necessarily consider--and what those promoting solar must consider--is the possibility that the market value of a solar installation (in terms of resale of the property) may be less than the costs associated with it, and that loans offered will therefore be a proportionally smaller part of the additional sales price. Such a disparity between costs and value would not be unique to solar energy systems, and is in fact a familiar part of housing market experience. There are many examples of what lenders often call "overimprovements"--housing features with costs greater than market value. Whether or not a particular feature is an "overimprovement" will vary among areas: in some neighborhoods a swimming pool, for example, may add as much to value as costs, while in others it would be an overimprovement. The question at issue here for those concerned with marketing solar housing is the extent to which lenders will treat the additional costs involved in solar as such an "overimprovement" and thus exclude it from property valuation in determining the maximum amount they will lend.

Economic Obsolence: In some cases the likelihood of technological or economic obsolence--that is, the development of better or cheaper systems--is an equal or greater concern in the property valuation decision than the possibility of performance failure.

Over time, of course, the market place will serve as the definitive abriter of value, with the known, unknowns, virtues and liabilities of solar systems reflected in the price consumers are willing to pay for new and used homes that incorporate solar energy devices. But right now, and for the next few years, this information will be lacking in most markets, and lenders will have to proceed in the absence of any significant volume of experience in the sale of "comparable" homes.

The question of valuation is obviously a crucial one. Although lenders may emphasize that it is the market that establishes value, their judgments and educated guesses as to what market value is will be unusually important until there is the "body of experience" that they (and most everyone else) is waiting for.

Lender Concerns -- Technical Performance: Another of the lender concerns deals with the problem of technical review of solar energy systems, and of the presence or ease of conversion to a standard heating system. Financial institutions generally lack the motivation, and in many instances the skills to examine the technical details of construction--including basic mechanical systems--with the same care they devote to assessing the marketability, value and overall livability of homes proposed for mortgage financing.

Where special needs arise, a detailed engineering review will be undertaken using an outside consultant if necessary. Such a review is generally the rule in large, complex multi-family projects, but a rare exception in a single-family house and smaller rental developments. The need simply does not arise.

However, when lenders receive their first loan requests on solar heated homes, they are confronted by a situation where uncertainties regarding the mechanical reliability of the heating system itself do, in fact, have a direct bearing on the value of peoperty as security for the mortgage. In many cases, before a lender will consider financing a significant part of this solar first cost as part of the total mortgage, he will probably require a thorough engineering appraisal of the system proposed for installation--possibly at the borrower's expense. Where the lender can't make such an evaluation, or sees it as too much trouble to obtain for a single loan request, he may be even more conservative in respect to the terms on which financing will be provided, if it is provided at all.

One possible solution to concern over performance failures that has been suggested is the provision of "warranties" by solar manufacturers, installers or home builders. But lenders attach little if any importance to the availability of a warranty for solar products. They tend to believe that if the manufacturer is a small company with limited economic resources, the warranty would prove of little or no value (even if the firm was still in business when the problem arose). Conversely, if the producer is large and reputable, the warranty is viewed as largely superfluous since the firm will, in most cases, feel obligated to stand behind its components--particularly in light of the stiffening legal context of implied fitness and warranty of products. On the other hand, the entry of major companies with national reputations into the field might help make the difference in many cases. Lenders would obviously feel more comfortable with a name manufacturer of established reputation, who was certain to remain in business over the life of the system.

Lender Concerns -- Estimating Energy Savings: There is one further "technical" issue of central concern to borrowers and lenders in the financing of solar housing: the manner in which projected utility cost savings are taken into account in financing decisions. The expectation of operating cost savings is the very aspect of solar energy systems that holds the promise of their widespread adoption in housing. But at least at the outset, there are likely to be some real problems raised by lenders' treatments of these projections in the evaluation of multi-family rental properties, and in their use for gauging the value of single-family installations and underwriting applicants for home mortgages.

"Income" (Multi-Family) Properties: In most instances, lenders employ the "economic" or "income" valuation approach to assessing mortgage loan requests for income-producing properties such as rental housing developments. No matter what precise valuation technique is employed, solar heating's impact on the attractiveness of a project for mortgage financing will be reflected in a straightforward manner since the estimated solar costs and savings enter directly into the net cash flow equation (income less operating expenses and mortgage debt service).

As part of his loan application, the developer will have submitted a detailed pro forma for the proposed development--that is, a statement itemizing the major constituents of gross income and expenses. A large part of the first costs for the solar energy system will be reflected in the line item for annual debt service (amortization of loan principal plus interest). Other components of total expenses--particularly the allocations for repairs and maintenance, utility costs, real estate taxes, insurance, and any reserves for replacement or other contingencies--might also be affected to some extent by the inclusion of solar heating. By the time serious developer interest in using solar heat for rental units materializes, these estimates may prove relatively easy to verify based on actual operating experinece with specific systems in single-family homes, other types of commercial properties, and government demonstration programs. However, for lenders at the present time, it would be difficult to devise a credible financial projection for a solar heated development. Since economic feasibility is based entirely on cash flow, the income stream would have to be determined "within reasonable probability". Otherwise the cash flow projections would have to be discounted heavily in the appraisal process--or the project rejected altogether.

Most lenders indicated they would in fact ask for (or prepare themselves) income statements comparing the project's economics both with and without the solar system. For valuation purposes, net operating income under both solar and conventional alternatives would be examined solely on the basis of current utility prices, with no allowance for fuel price inflation over time. This is consistent with general practice for quantifying other components of cash flow which may well vary unpredictably from year to year, such as real estate taxes, wages for security and maintenance personnel and the basic rent schedule for the units themselves.

From the lender's perspective, the larger scale of multi-family development makes them a more risky setting to try out solar energy technologies for the first time. However, as the economics of solar use become more favorable, system adoptions may spread even faster in the multi-family than in the single-family sector. The developers of multi-family housing and the lenders who finance them are highly sensitive to energy costs and eager to adopt any innovation that will convert their costs fo fixed rather than variable expenses. Thus, whenever the economics of solar installation begin to become truly competitive with conventional heating, one can anticipate a relatively rapid rate of acceptance of solar heat on the part of those who underwrite income properties.

"Sales" (Single-Family) Properties: While the valuation of income properties automatically reflects energy cost savings in property appraisal, this is not generally the case where single-family and other "sales" housing is concerned. In appraising the value of such housing, lenders normally look to information on the sale of "comparable homes". However, in the case of solar homes, this information will be lacking for several years, and lenders will be reluctant to use "replacement costs" (that is, the price of the solar installation) as an alternative indicator of value. Given the inapplicability of these usual appraisal measures, some lenders will turn to consideration of energy costs savings as a partial if not wholly satisfactory surrogate. But they will necessarily encounter many of the same problems involved in the valuation of income properties--and can be expected to handle in a similar manner.

Solar first costs can be determined with some reliability, but in reviewing estimates of fuel savings with solar heat, the lender must contend with the claims of manufacturers and developers which he suspects may be inflated and self-serving, or else obtain "educated guesses" from more disinterested experts. Lenders will tend to discount the estimates to some degree, and to resist the use of projected increases in alternative fuel costs.

The approach to valuation will vary considerably, from payback period and lifecycle cost analyses to the "capitalizing" of estimated savings and discounted cash flow approximations of present value. None of these types of analysis was viewed as determining the decision on whether to loan or not, but rather as partial guides in appraising value.

Where a permanent mortgage has been requested, the loan officer has an absolute assurance that the cost of a solar system is worth the going price to at least one consumer--namely, the purchaser himself. Speculative sales housing raises different issues, with some lenders feeling that the absence of "an actual buyer in hand" makes the situation too risky. The construction lender may question the ability of the developer to successfully market solar-heated homes on a speculative basis in other than luxury markets--regardless of how attractive solar heat may or may not be from an investment point of view (payback periods,etc.).

Some loan officers indicated, however, that at first they will be even more likely to finance a developer than a home buyer. In their view, the developer will have already applied his considerable professional expertise to evaluating both the technical performance of the system he has selected and the marketability of the resulting product. When that "credible developer" arrives, banks surveyed will have no trouble lending to him--but they don't generally expect him to appear tomorrow.

Lenders will be even more inclined than usual to make financing available only to those developers with whom they already have a working relationship, or who have a sound and established reputation, and to those who have financial resources of their own sufficient to handle any serious difficulties that might arise in the installation or operation of the solar energy system. And in those few cases where lenders do decide to finance speculative homes with solar heat, they will most likely restrict the builder to only one or two units at a time.

Availability of Mortgage Financing: Lenders appear generally receptive to mortgage requests on solar homes. Few will reject such a request outright without at least having first considered the specifics of the proposal. But the terms on which financing will be offered will vary considerably, depending on the type of project, the specifics of the proposal, and the attitudes and experiences of the particular institution involved.

Credit Review Procedures--A Bias Against Solar?: The skepticism of lenders regarding the reflection of solar costs and savings in property value will surely be the primary problem for "average" home buyers who want to go solar. But there is another problem as well which has to do with the way lenders evaluate a borrower's capacity to pay off a mortgage loan.

Most lenders use a comparison of projected housing costs to loan applicant income as a guide to determining the maximum size loan for which a given individual can qualify. The widely followed standard is that housing costs should not exceed 25% of income. But in most cases, this calculation of housing costs does not include energy costs, and is limited to Principal and Interest payments on the loan, Property Taxes, and Hazard Insurance presiums (thus often referred to by the acronym "PITI"). The resulting problem for solar homes is that savings in utility bills will not improve the borrower's financial capacity as evaluated by the lender. At the same time, the higher first costs of the property, as reflected in a higher mortgage request (and higher principal and interest payments), and higher insurance premiums and property taxes, do raise the income requirements as established by the PITI test.

Hedging Against Uncertainty: Until more market experience accumulates on solar homes, most first mortgage loans will be made in amounts that leave out part of the additional costs attributable to the solar system.

Financial institutions will, in many situations, be prepared to lend on solar heated homes. However, for as long as the data remains shallow on system performance and market value, lenders proceeding with such loans will find some way to hedge their risks in the specific terms and conditions which financing is estended. Loan officers emphasize that the mortgage "is a very flexible instrument". Above all, this flexibility resides in the ability of the lender to limit his exposure by reducing the loan amount as a proportion of actual costs. This can be accomplished in several ways:

1. By appraising the property at a value lower than its cost or selling price;
2. By offering the borrower a lower than normal loan-to-value ratio, or
3. By both methods combined.

The net effect of these methods of risk reduction when applied to financing requests for solar homes will be to impose higher down payment requirements on prospective homeowners and necessitate larger contributions of equity from developers and housing investors.

Federal Credit Agencies and Solar Energy Financing

At the present time, the FHA is actively developing its position in regard to the terms under which properties with solar energy systems will be eligible for its guarantees--most importantly under its Section 203 program (the basic program for insuring unsubsidized private lender financing of single-family homes) and the "Title I" insurance program for property improvements and mobile home purchases. The provisions of the property improvement program were specifically amended in 1974 to make expenditures on solar energy systems eligible for loan insurance. FHA is well along in the process of incorporating standards for solar systems into their Minimum Property Standards. In addition to these specific initiatives, FHA, as part of HUD, is more aware than most other mortgage market participants of activities being undertaken as part of HUD's Residential Solar Heating and Cooling Demonstration Program.

Since FHA deals on the average with a lower-income range of homebuyers, energy costs have long been included in housing expenditures as part of the agency's underwriting procedures: the more "marginal" the loan applicant, the more important energy costs appear in assessing his capacity to meet mortgage payments. More recently, the 1974 Housing Act added a new requirement that energy saving techniques be promoted "to the maximum extent feasible" through the Minimum Property Standards for newly constructed housing. But Solar energy systems are distinguishable from conservation measures such as increased insulation, on a number of obvious grounds--such as much higher first costs, and the lack of experience with individual systems--and the FHA will be taking a far more cautions approach to them at the outset.

Although the FHA is insuring lending institutions against their possible losses, the purpose of the mortgage insurance program is to improve the terms and availability of financing for purchasers. Thus FHA officials perceive themselves to be acting on behalf of the home buyer, and, in discussing the issues related to residential solar energy system, emphasized that they must put themselves "in the homeowner's corner". The principle of the acceptability of Solar energy systems has been accepted statutorily, administratively, and the FHA's position is now available with the issuance of the Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems (issued by HUD in 1977).

Appraising the value of individual systems presents the same problems for FHA as it does for the banks, but with the added emphasis on "protecting the buyer" alluded to above. General instruction on appraisal has been given, but without any specific formula mandated. Variation and flexibility are expected as the best approach to appraisal as these systems evolve, nevertheless, a tendency toward relatively conservative estimates of value seems likely to prevail. This attitude is already reflected in the provisions of FHA notices to their field offices, which state: "The field office must also determine that a ready market exists for the property with the increased cost of the solar equipment. The cost of this additional equipment may be recognized in value in an amount that can be demonstrated by an analysis of the market. Potential savings in operating costs are also a consideration in determining acceptability in the market...".

FHA representatives in a field survey note that the merchandizing of home-improvements has historically been "subject to wide abuse". They cited fire detection systems, burglar alarms and "waterproofing" as examples of housing features that were often installed at "outrageous costs", far in excess of resale value. And the attitude of FHA also appears to have been strongly affected by the severe loss rates in recent years with its insurance programs which were designed to bring lower-income families into the housing market by providing for extremely small downpayments and, in some cases, the lowering of credit standards. The lesson drawn from this experience is that, problems of fraud aside, the lower the true equity of the homeowner--that is, not simply his investment, but the actual difference between outstanding debt and value--the higher the default and foreclosure rate. FHA officials do not want to do a similar "disservice" to homebuyers or to their own programs by appraising solar systems at full cost where the market value is or may be less than cost.

The impact of the FHA position will probably be larger than its market share suggests, in view of the agency's visibility and the widespread use of its Minimum Property Standards by homebuilders and lenders.

In respect to retrofit finance, the influence of Title I will, in all likelihood, be fairly limited--particularly in those regions of the country (the West and Southeast) where lenders find the program's ceiling on interest rates uncompetitive.

Secondary Institutions and Solar Energy Financing

Federal National Mortgage Association: In contrast to FHA, the two principal secondary market entities--the Federal National Mortgage Association (FNMA) and the Federal Home Loan Mortgage Corporation (FHLMC)--give primary lenders a fair degree of flexibility and discretion in their evaluation of credit worthiness, appraisal of value, and overall review of the property's acceptability for mortgage purposes. However, this discertion should not be confused with liberality. These secondary entities perceive their basic public functions--i.e., contributing to liquidity in the mortgage market and stabilizing the flow of capital into housing production--as necessitating a conservative stance toward underwriting the risks associated with unproven housing technologies. Nor are they inclined to undertake unilateral initiatives to promote specific social objectives such as energy conservation.

At the same time, the management of both organizations recognize that while their institutions may be privately owned, they nonetheless were established and continue to serve as instruments of Federal housing policy. As such, they feel an obligation to be responsive to Presidential and Congressional appeals for their cooperation in advancing public objectives (lower housing costs, energy conservation) that may lie outside their explicit mandate.

So far, neither FNMA or FHLMC has yet made any formal study or issued any explicit policy in regard to underwriting solar heated homes. When describing the policies that would most likely be imposed, officials conjectured that most, if not all, of the incremental solar cost might be excluded from mortgageable value and that high loan-to-value loans on solar homes would probably be refused while the technology remains in the experimental stage. In the absence of external inducement, neither organization is likely to take any strong initiative to clarify and publicize the eligibility of solar heated homes for purchase or otherwise encourage solar heating.

In general, the guidelines of both secondary entities caution against financing the atypical home that differs conspicuously from its neighbors in price and in its basic style and features. For example, FHLMC's guide to its underwriter states that "... properties varying from the norm should be reviewed carefully as to marketability, how well they fit into the neighborhood price structure, and their acceptability as to architecture and amenities offered. Those that are not typical may have market resistance and should be underwirtten on a more conservative basis as to overall loan terms."

The policies of FNMA, which purchases up to $7 billion of mortgages annually, may prove significant--particularly in those regions of the country where mortgage companies are most active.

In the absence of explicit communication from FNMA and FHLMC regarding residential solar energy technologies, at least some of their approved sellers may refrain from writing any loans on solar heated homes, particularly if the borrower is seeking a relatively high lona-to-value ratio mortgage and financing for the incremental solar first cost. This observation applies most directly to mortgage companies, who compose most of FNMA's seller population. The profitability of such companies depends in large part on packaging loans for sale on a volume basis; consequently their lending criteria are largely dictated by the requirements of FNMA and the other purchasers for their mortgages.

By contrast, FHLMC functions as an in-house secondary market almost exclusively for the savings and loan industry. While the lending policies of the savings and loan associations have become increasingly oriented towards ease of saleability in the secondary market, most savings banks still retain most of the loans they originate. Thus their receptivity to mortgage requests for solar heated homes should be relatively unaffected by FHLMC attitutes, at least until they begin to receive such requests in substantial numbers.

Neither FHLMC nor FNMA's credit standards includes utility costs in the basic calculation or monthly housing expense for single family homes. However, allowance for utility costs is made under some circumstance and information on such costs is routinely collected on the standarized application forms now in use. For example, FHLMC procedures define a housing expense ratio (Principal, interest, taxes, insurance) of about 25 percent of stable monthly income as acceptable. Over the past few years, as energy costs have risen, FHLMC in its own underwriting has been giving more attention to heating expense, especially in marginal cases where the borrower's total indebtedness approaches or exceeds the formal ratios. On the other hand, it is unlikely that a lender concerned with FHLMC eligibility would relax the 25 percent guideline on his own initiative to allow for the prospective energy savings a borrower might realize from an investment in a solar system. However, officials at both FNMA and FHLMC indicated that they would consider making adjustments for estimated savings on a case by case basis.

Private Mortgage Insurance Companies: Private mortgage insurance companies (PMI's) offer the lender different risk-sharing arrangements in terms of the extent of exposure, absorbing various proportions of the "top-part" of the risk. Premiums are scaled to the percent of PMI coverage and the total loan-to-value ratio (which reflects the amount of risk covered by the home buyer's equity position). Unlike FHA, PMI's rely directly on the underwriting of property and borrower done by the lender and only spot-check individual situations with their own appraisers. PMI's look to builders and developers as a means to develop business with banks, and will review and "pre-approve" a large development, such as a condominium or planned unit development, in advance.

Given the nature of PMI operations, they are unlikely to establish any special programs for handling solar energy equipped homes, and are even less likely to be an obstacle in their development. They may even play a positive if perhaps unintentional role in accelerating their acceptance.

First, PMI's are in the business of insuring higher risk loans and appear likely to accept solar homes as a matter of course. Moreover, the likely number of such homes involved and the uncertainties associated with them, when measured against the total volume of PMI operations, are not viewed as substantial enough to warrant any major independent technical review by the PMI's themselves.

Second, as one lender put it, appraisal is "not a mechanical process", and the awareness of the option of sharing the risk with a PMI may at least offset any initial tendency to place a "conservatively low" value on solar energy systems and houses using them.

Third, it is possible that PMI's may even welcome the advent of solar homes as an opportunity for market expansion; banks with little or not experience with private mortgage insurance may turn to PMI's in such cases, and they in turn will insure loans as part of their own market growth programs.

Thus, though PMI's have no plans at present for any "outreach" program to solicit loans on solar homes, it appears that if they have any impact on the availability of financing, it will be a positive one.

Is Financing A Problem?

Financing As A Constraint: The discussions of lenders and solar energy financing to this point have been addressing the frequently voiced belief that financial institutions tend to react conservatively to new technologies and may prove to be a constraint on the market acceptance of residential solar energy systems. While the discussions give partial support to this view, they raise a number of qualifications that may be of equal importance to those engaged in advancing solar energy use.

The major points can be restated simply as follows: In many, if not most cases, lenders will make loans available for solar equipped homes, where the borrower and property satisfy rountine underwriting standards. But, so long as the technology remains in the experimental stage, they will often be willing to make such loans only if their risk is reduced by limiting the loan amount to a smaller than normal portion of total costs. This represents the likely policy not only of private lending institutions, but also the FHA and the quasi-public secondary market entities, FNMA and FHLMC.

Does this limited availability of financing impose a constraint on the size of the residential solar energy system market or on the rate at which sales to that market will grow? It certainly does if compared to a hypothesized set of circumstances in which the average borrower would be able to get "full" financing of these costs--an average loan-to-value ratio, and a full inclusion of solar energy system costs in appraisals. And it is generally recognized that the size of the market for housing at any given cost bears an inverse relationship to the amount of downpayment required. Thus the terms under which financing is now available for new single-family housing is likely to be a constraint, limiting the market to that smaller proportion of home buyers able to put up a larger portion of the additional first costs involved.

The following table shows the quantitative implications of this constraint for the prospective purchaser of a new home with an $8000 solar system.

	% OF SOLAR COST IN APPRAISED VALUE	LOAN/VALUE RATIO		
		CONVENTIONAL LOAN		FHA INSURED LOAN
		70%	80%	97%
Net Addition To Downpayment For Solar Use	100%	$2400	$1600	$ 560
	75%	3800	3200	2420
	50%	5200	4800	4280
	25%	6600	6400	6140
	0%	8000	8000	8000

Impact of Below Cost Appraisal and Lower Loan-to-value Ratios on Downpayment for New Home With An $8000 Solar Energy System

In respect to new rental housing, lenders recognize that imposing higher equity requirments for solar equipped projects will in many cases be tantamount to declaring that one has no real interest in proceeding with the project. In the aftermath of the real estate market collapse of 1973-75, financial institutions have already moved to require a larger investment from the developers with whom they work. Even the strongest developers generally have a limited ability to raise this additional front-end capital from their personal resources.

Lender Attitudes Or Solar Cost?: The problem of below-normal loan amounts largely reflects the lenders' central and legitimate concern with the collateral value of solar homes, given the current solar state-of-the-art --and not some "defect" in the mortgage market or an unreasoning resistance to new technologies. In all likelihood the first costs of most solar installations today are, in fact, greater than their contribution to a home's resale value, and substantial performance risks will remain for at least a few years more.

If this view is accepted, it is still apropriate to consider public programs that affect the terms and availability of finance. But such programs would then be designed with the broader problems of solar economics and national energy policy in mind, and not in order to overcome an imperfection in the mortgage market.

Builders, Developers, And Solar Energy Financing: The questions considered above are only part of the many problems confronting solar users and solar proponents as they strive to make this energy source a practical alternative today. In terms of the specific issues related to the financing of solar housing, however, it is important to note that lenders believe that the impetus for change will come from builders and developers, if it comes at all. They already view them as the lead actors in the advent of energy conserving initiatives generally, and have reason to believe that this will be the case in solar as well.

If builders find that energy conservation in design is in their own interest, lenders expect that "they will sell it to home buyers" (and to lenders, too). On the balance, lenders seem to feel that developers, whose success depends to a large degree on their constantly seeking a marketing edge over their competitors, have a stronger incentive than financial institutions to keep abreast of new housing technologies. Lenders presume that any experienced homebuilder will have thoroughly investigated solar systems from a technical viewpoint and convinced himself of their marketability, before ever having decided to build solar heated homes or approach a bank for financing. When commercial interest does materialize, the lender would expect the developer to make a complete presentation of his grounds for believing solar systems are feasible, and to supply much of the technical data needed to make a property appraisal and arrive at a final lending decision.

The builders and developers of single-family housing may thus be the wedge that opens the mortgage market for the wider development of solar homes. But solar manufacturers and designers will have to convince builders of the reliability and saleability of their systems, and show them how solar homes will be better for them--as housing entrepreneurs, not as public minded energy conservationists.

GOVERNMENT INCENTIVES

Most of the preceeding has been devoted to factors influencing the development of solar building systems by the private entrepreneur to satisfy individual consumer demands. There are potential benefits associated with solar energy, however, which may be of marginal importance to the individual, but of transcendent importance to the nation as a whole. These benefits relate primarily to energy conservation and pollution abatement. If there are elements of the free-market climate which mitigate against active promotion of solar systems for buildings, incentives to development may be necessary for the furtherance of national objectives.

Government Policy: One of the attractive features of onsite solar equipment is that it may be the only new energy source that can be developed, financed, and installed without Federal assistance of any kind; it is simply an extension of the existing construction industries. Federal energy policy will, however, affect the rate at which onsite solar energy enters the market, regardless of whether an attempt is made to develop a specific policy for solar energy. Federal policies have made the market in which solar technologies compete an artificial one. Energy prices are influenced by a bewildering array of regulations, subsidies, and controls, which, in several instances, have had the inadvertent effect of reducing the attractiveness of solar equipment. Examples include the policy of maintaining residential energy rates at artificially low levels, decisions to support large types of energy equipment with preferential tax credits, and disproportionate amounts of research funding given to larger energy equipment.

There is little doubt that without Federal assistance, solar markets will grow relatively slowly. Legislation can greatly accelerate the rate at which this market grows. Many policies are in various stages of planning and implementation, and four categories are related to financial issues: subsidies, tax credits, low-interest loans, and mandatory issues. However, before considering these areas in more detail, the high investment cost of solar needs to be addressed.

Capital Market Deficiencies: Solar energy systems often require a much higher initial investment than the alternatives. A problem arises because individuals are unable to borrow against future savings. For example, a solar energy system usually has a higher initial cost than the alternatives, but will result in significant cost savings over its lifetime. If the system and its alternatives were evaluated on the basis of lifetime costs and savings, the more expensive system would be chosen. However, potential investors must come up with the initial capital payment. If the investor does not have the entire amount available, the balance must be obtained from lending institutions. Lending institutions make decisions based on current financial information, such as the amount of collateral and outstanding debt of the potential investor. Future amounts, such as anticipated pay raises or the savings provided by an energy system, are not considered. Thus, an investment that might provide significant returns or savings during its lifetime may not be undertaken because of a relatively high capital cost.

This problem is not unique to the solar energy industry. Young people attempting to obtain education or purchase housing cannot use their future increases in income as collateral. If individuals were able to borrow against the future increases in income attending school would provide them, they might choose to attend a more expensive college than would otherwise be the case. However, since loans are based upon current financial status, these individuals are constrained to utilize a less expensive route.

Options that might be used to resolve capital market deficiencies would offset differences in initial costs. Such solutions include subsidies, tax credits, and low-interest loans. However, these solutions tend to transfer the gains and losses associated with solar energy usage. By receiving a subsidy, investors are given a further incentive to undertake investments that are profitable to them. Thus, the individuals who obtain this subsidy gain in two ways--from the subsidy itself, and from the additional benefits the more efficient investment gives them--while the provider of the subsidy, who is often a different individual, foots the bill.

Another possibility is to provide a special pool of loans for solar energy systems. If an inability to borrow against future savings is inhibiting solar energy system adoption, the avialability of such a loan pool would resolve the problem. The potential investor should still be willing to undertake solar investments if the perceived savings are expected to be large enough. Furthermore, if these loans were made available at the same interest and payback criteria as other loans, those who provided the loans would not be subsidizing the potential investors.

Subsidies

What Are Subsidies?: A subsidy, by economic definition, means government action which provides income given to a person or group to support and encourage activities that are deemed beneficial to the public. Subsidies vary all the way from those given to the poor, such as rent subsidies, to those given to farmers and to landowners who are frequently quite wealthy.

Economic Impacts: What are the economic impacts of government subsidities for solar energy? Financial incentives do little to reduce economic uncertainty; measures such as guaranteed loans merely shift risks from buyers to the underwriters. Subsidies encourage innovation to the extent that consumers are willing to buy newer systems that are not cheaper. If the price of nonrenewable energy sources is artificially low (because of regulated prices, environmental impacts that are not considered, etc.), subsidies to solar energy will promote efficiency in choices among energy alternatives.

The main strength of subsidies is that they offset capital market problems caused by the high initial cost of solar energy systems relative to the alternatives. If loans are difficult to obtain for projects that promise significant net returns, high initial costs distort choices among alternatives. Subsidies can offset these distortions.

The equity aspects of solar energy subsidies are not clear. If solar energy users tend to be relatively high income individuals, and relatively low income groups tend to use conventional fuels, solar subsidies will aid relatively high income groups. Furthermore, if the subsidy takes the form of a tax credit, such an incentive is only effective when the purchaser has tax liabilities greater than the credit. Thus, the impact may not be the desired one, since higher-income groups tend to have larger tax liabilities.

One of the main difficulties with subsidies is that they encourage the activity that is subsidized. While it may be true that solar energy subsidies merely offset the financial advantages enjoyed by other fuels, such subsidies also tend to make energy utilizing activities more attarctive. Thus, subsidies tend to promote a larger amount of energy usage than would otherwise be efficient. Finally, subsidies are not inexpensive. While some financial incentives (such as grants) require direct outlays of money, and others have more subtle and indirect consequences (tax credits and low-interest loans), all these incentives use resources that might have been devoted to other activities.

Government Subsidy Policies: Legislation at the local, state, and federal levels is in effect or being planned for a variety of government subsidy activities in connection with commercialization of solar energy. The following types of policies can be effective;

1. Direct incentives to potential customers (chiefly tax incentives, loan subsidies, and allowances for accelerated depreciation).

2. Assistance to manufacturers (including incentives for purchase of manufacturing equipment, research and development grants, and Federal purchases) and assistance for testing laboratories certifying the performance of onsite equipment.

3. Support of basic research and development programs in fields related to onsite solar energy.

4. Encouragement of the use of solar energy in other countries through foreign assistance grants, joint research programs and other techniques.

5. Programs to support education and training in fields related to solar energy.

However, tax credits and low-interest loans are the two principal forms of government subsidy that affect the public at large.

Tax Credits

Tax Laws: Two tax mechanisms have the greatest impact on a homeowner who is planning to install solar heating. First, he must pay sales taxes, or "use" taxes, on the materials used in the solar components, and then pay increased property taxes on the added value of his solar installation. In addition, tax laws can affect local businesses in several less obvious ways, such as by increasing their income tax liability because of the lower operating expense associated with their heating needs.

Opinion seems unanimous that solar equipment will add to a structure's assessed value. But to include this addition in assessments made to determine the amount of tax to be levied on a property may be unfair. Many states have passed, or are condidering, legislation that addresses this problem. Enacted laws typically say that solar equipment shall not cause an increase in the valuation of a building.

There may be general legal problems with exempting solar equipment from property tax assessments, since the majority of states have what are known as "uniformity clauses" in their constitutions and/or in their tax laws. Uniformity clauses say that all "similarly situated" property or the "same class of subjects" must be taxed at the same rates. The language and the interpretation of such clauses vary widely from state to state, making it very difficult to predict the success of an effort to exempt solar heating and cooling equipment. In some states, constitutional changes may be needed.

Furthermore, legislation is usually vague on how backup heating systems should be assessed. In most climates, building and health codes require structures with residential occupancy to be equipped with heaters capable of warming habitable rooms to specified temperatures. Requirements vary greatly, but as massive solar storage systems capable of outlasting weeks of cloudy weather are not cost-effective, most solar homes will require backup systems.

One popular type of state legislation says solar homes shall be assessed as if equipped with a conventional system or "at no more than" the value of a conventional system. Such laws could be interpreted as requiring a "double assessment", i.e., the value of the backup system plus the adjusted value of the solar system.

A similar precision should be sought in statutory definitions of "solar energy system" and like terms. Not only should the exclusion (or inclusion) of legally required backup systems be specified, but it should be made clear whether passive solar systems are also to receive preferential tax treatment.

State legislation should also be cognizant of the fact that some assessments are made on the basis of a property's income production.

Government Tax Policies: Tax credits, low interest loans, accelerated depreciation allowances, and exemption from property tax can be powerful tools in reducing the perceived cost of solar energy. A 20% investment tax credit, for example, could reduce the effective cost of solar energy in residential applications by 15 to 30%. The combination of a 20% investment tax credit, 5-year depreciation allowance, and an exemption from property tax, could lower the perceived cost of solar energy by 50 to 80%. A program making 3% loans available to homeowners would be equivalent to an investment tax credit of about 34%. These subsidies would have the effect of increasing sales, resulting therefore in a decrease in the cost of individual components if they stimulate mass production. Tax credits reduce Federal revenues but the net cost of the credits to the Government is difficult to calculate.

The Energy Tax Act of 1978: On November 9, 1978, Congress passed the National Energy Act (NEA), composed of five separate statutes, one of which was The Energy Tax Act (ETA). The Energy Tax Act utilizes financial incentives to decrease the initial capital cost of solar energy systems. Homeowners may take a residential energy tax credit of 30% on the first $2000 they spend for solar energy systems and 20% on the next $8000 they spend. Businesses may take an investment tax credit of 10% on the cost of qualifying solar energy property (in addition to the usual 10% investment tax credit on new facilities). These tax credits will indeed reduce the cost of solar energy systems. However, subsidies do not guarantee that a system becomes viable. While financial assistance may reduce the initial capital cost, it cannot guarantee that solar energy systems will be cheaper to use than the alternatives.

Furthermore, tax credits have equity problems associated with them. For the tax credit to be effective, homeowners and businesses must have tax liabilities that are as large as the credit. This is because the tax credit is not refundable. If homeowners have a larger tax credit than they have tax liabilities, they cannot receive the difference as a refund from the Internal Revenue Service; this amount must be carried forward or backward on income tax statements.

There is also confusion as to the definition of systems that do qualify for the credit. Because of the difficulty in distinguishing between structural and pruely energy conserving elements of a passive system, passive solar energy systems were omitted completely from the tax credit. Thus, any passive solar system components such as roofs, windows, walls, skylights, and greenhouses are not eligible for the credit. Since passive energy systems represent a major source of conservation potential, this exclusion reduces the potential energy savings a solar tax credit would allow. However, such passive systems often represent the cheapest form of energy savings. Since the marginal cost of utilizing passive solar energy systems is low, it would be efficient to encourage these systems rather than systems that must include both a structure and energy-saving technology. Thus, the proposed rules restrict residential energy tax credit effectiveness by limiting applicability to those portions of the solar system whose primary purpose is to transmit or use solar radiation.

Double Benefits?: State and local government financial incentives for energy conservation and renewable resources have become quite common and, sometimes, quite generous. But, unless an individual is extremely cautious, the tax consequences of choosing the wrong combination can be disastrous.

A little known section of the Windfall Profits Act of 1980 could significantly affect the future of conservation and solar energy. Titled "Provisions to Prevent Double Benefits", Section 203 applies to residential users and states that "for the purposes of determing the amount of energy conservation or renewable energy source expenitures made by any individual with respect to any dwelling, there shall not be taken into account expenditures that are made from subsidized energy financing". Section 223 spells out similar restrictions for commercial enterprises. (Subsidized financing means financing under federal, state, or local programs designed to conserve or produce energy. Favorable terms on loans from banks and utilities will not affect federal tax eligibility as long as there is no government subsidy involved.)

The Internal Revenue Service (IRS) is responsible for developing regulations to implement this provision, and at the present time (late 1980) IRS has not yet released preliminary rules. However, IRS personnel lean toward the theory that if any part of a loan is subsidized, the entire loan is ineligible for federal tax credits. If a utility, for example, provided a low interest loan for the purchase of solar collectors, the principal of the loan as well as the interest would be considered subsidized energy financing and would not qualify for the solar tax credit.

This prohibition on double-dipping will force a solar system purchaser to choose between the federal tax credit and subsidized energy loans.

Economic Impacts: Tax and subsidy considerations are a major driving force in market choices among energy alternatives. Taxes and tax-reduction measures (such as depreciation and depletion allowances, investment tax credits, etc.) will change the cost of utilizing energy resources to industry. While taxes may not change the actual opportunity costs of extracting energy, they very definitely change the costs perceived by firms.

For example, Figure 1 might represent the supply and demand effect resulting from the adoption of a depletion allowance. Prior to the allowance, the opportunity costs associated with extracting resources would be represented by the supply curve S, and the equilibrium market price would be P_0. This curve slopes upward to the right (i.e., price P, increasing as supply quantity, Q, increases) because additional output of the resource can only be obtained by utilizing less productive deposits of the resource or by utilizing inputs that may not be as productive in extracting the resource. However, a rule that would allow the industry a tax reduction on each unit of the resource it produces (as the depletion allowance does) would decrease the costs to the firm of providing the resource. Although the actual opportunity costs of supplying the resource may be S, the costs perceived by industry are S', and equilibrium market price would reduce to P_1. However, depletion allowances increase the amount of the resource utilized, i.e., equilibrium quantity, increases from Q_0 to Q_1.

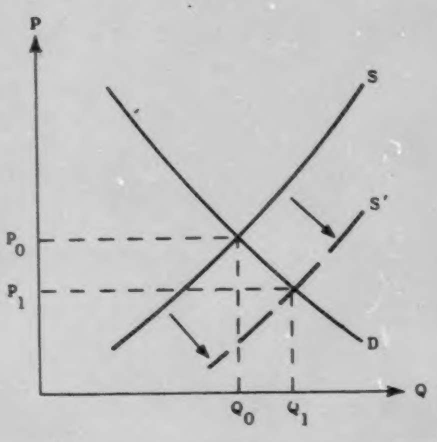


FIGURE 1

The opposite conclusion is reached when a depletion allowance is removed or a resource extraction tax is imposed, as illustrated in Figure 2. The actual opportunity costs of utilizing the resource are represented by S. However, the costs as seen by industry are represented by S'. Thus, the amount of resource utilized falls (from Q_0 to Q_1), and some of these higher costs are passed on to the consumer (P_0 to P_1).

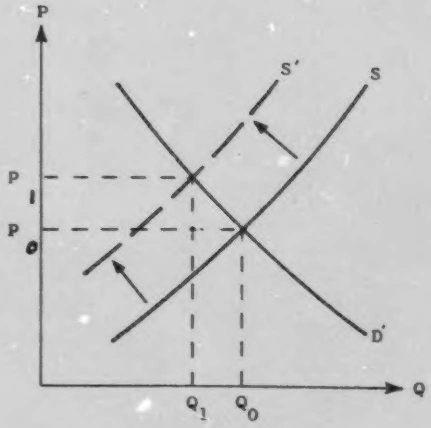


FIGURE 2

These market distortions are fairly common in the energy field. A wide variety of depletion allowance provisions has been available to the fossil fuel industry. Other incentives have included foreign tax credits for oil production, research and development support, and liability insurance for the nuclear enrgy industry. Such distortions have resulted in the overuse of the subsidized products, which have tended to be fossil fuels and uranium. These price distortions have also resulted in the diminished usage of alternatives, such as conservation and solar energy.

One possible solution to the problems created by price distortions is the removal of the taxes and subsidies that cause these distortions. Such a solution is overly simplistic; it will not, in the short run, alleviate basic energy problems and may create inequities in society. Many billions of dollars of investment have been based upon these energy prices, however, artificial they may be, so that the economy could not rapidly respond to abrupt price changes. This could, in turn, result in large changes in wealth among income groups within society. Thus, although the absence of market distortions allows consumers and firms to make energy decisions efficiently, rapid changes in existing distortions are also costly.

Low-Interest Loans

The Solar Energy Bank: By an act of Congress during 1981, a Solar Energy and Energy Conservation Bank was established for the purpose of subsidizing solar energy systems. The Solar Bank is a corporation within the U.S. Department of Housing and Urban Development. Its chief executive will be appointed by the president with the advice and consent of the Senate. It will have two executive vice-presidents, one to administer its solar programs and one to administer its conservation programs. Five cabinet officers serve as its board of directors: the Secretaries of HUD (chair), Energy, Treasury, Agriculture, and Commerce. The board's principal function is to fix subsidy levels, subject to the constraints and within the limits imposed by the statute. Funding for the bank's solar programs was authorized for three years beginning with fiscal year 1981 at \$100 million, \$200 million for 1982 and \$225 million for 1983. Annual appropriations, up to these limits, will be necesary.

Subsidy Provision of the Solar Bank: The Solar Bank is not really a bank, but rather a mechanism for delivering a federal subsidy payment in connection with a borrowing made to finance the purchase of solar energy equipment. The borrower must get his or her loan from a private source--a bank, savings and loan, utility company, or municipal corporation. The Solar Bank subsidy is then applied to reduce payments on the loan, either by lowering the interest rate or writing down the principal amount for the note. Solar Bank subsidies can be paid to purchasers of new residential buildings or owners of existing ones. They can be used to finance active or passive solar energy installations on one-to-four family houses. In the future, they will be used to finance multi-family, commercial, and agricultural solar equipment.

The amount of subsidy payable on a single-family residential unit is limited by statute to $5000. However, active and passive systems get different treatment in determing the subsidy level. The subsidy for active systems is calculated as a percentage of the system's cost. Passive solar energy systems will be subsidized on a performance rather than a cost basis. Purchasers of solar equipment with incomes of 80% median income and under can have 60% of the cost subsidized by the Solar Bank, up to a maximum of $5000. Under HUD draft regulations, individuals with incomes above 80% of area median income would be ineligible for subsidies for active, but not passive, solar systems.

Implementation of the Solar Energy Bank Provisions: The Solar Bank will have a three-step procedure for qualifying houses with passive solar elements for the subsidy and for determining the amount of the subsidy for a qualified house. Step one involves a determination by the local financial institution that the house is eligible for subsidy. The local lender will check to make sure that the house contains a solar collection area, an absorber, a storage mass, a heat distribution method, and heat control and regulation devices. Step two requires a measurement of the thermal effectiveness of the passive system, based on the three factors of south-facing glass area, floor area of the house, and level of insulation of the house. Step three involves the application of a factor derived from step two to a published table, which the Solar Bank will promulgate, that will assign different levels of subsidy for each of over 1000 geographic areas covering the United States (based on the Postal ZIP Codes), keyed to the thermal effectiveness of the passive solar system.

Mandatory Issues

Some proposals for expediting use of solar energy would require use of the technology in specified circumstances, for example, should utility financing of home insulation be required by all public utility commissions? Less draconian measures have also been suggested (and adopted in Florida) to provide that buildings are constructed so as to make the later addition of solar devices a little easier.

The principal legal questions governing the legality of such requirements is whether they constitute a "taking without compensation" in violation of the Fifth Amendment to the U. S. Constitution. Although this question is difficult to answer with any certainty, there are numerous precedents upholding requirements for building design and construction methods. However, the application of these ordinances to specific buildings may be held invalid where the property owner can demonstrate that the costs clearly exceed the benefit. Thus, while requirements for provision of solar energy are likely to be upheld in general, they may be invalidated in the case of specific properties. This is likely to be a much greater barrier to retrofit requirements than similar demands on new buildings, since the latter will generally be affected equally.

The federal government might become involved in mandatory installation requirements through the Minimum Property Standards of the Department of Housing and Urban Development. No additional legal barriers exist to prevent federal standards.

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CODES, LEGALITIES, CONSUMERISM AND ECONOMICS

LEGALITIES

STUDENT MATERIAL

CODES, LEGALITIES, CONSUMERISM AND ECONOMICS

LEGALITIES

GENERAL LEGALITIES

Solar energy, like any developing technology, must adapt to the existing customs and laws of our society, just as society must accommodate new technologies. Any incompatability raises legal issues that must be resolved before we satisfy our expectations for this promising source of energy. Some of these issues obviously concern national policies, while the importance of others are regional and local in nature.

In the United States there exists a world of laws, government, and politics which often (sometimes unintentionally) resticts our ability to use techniques such as solar energy conversion. Onsite solar facilities are controlled by laws and regulations often written with entirely different energy systems in mind. Since onsite solar equipment will undoubtedly be designed, manufactured, financed, installed, and operated by the same organizations currently associated with the construction of building and industrial facilities, the impact on American Society as a whole will probably be minimal. Several areas where impacts would probably be greatest, such as building codes, financial issues, and utility interfacing, has been identified and studied in some detail.

A technology with as many applications as solar energy will naturally both influence and be influenced by legal concepts. During the earlier stages of its development, solar energy will be influenced by existing law principally as it relates to buildings. Governments may also institute laws for policy reasons; for example, favorable provisions of tax laws designed to encourage the purchase of solar energy devices in residential and commercial buildings. Of immediate concern, however, are three issues bearing on commercialization of solar energy at the local level. These issues are concerned with solar access and land use, insurance, and competent labor for solar related applications.

SOLAR ACCESS AND LAND USE

Because faulty or improper land use may endanger the health and and welfare of an entire community, regulation and control over subdivisions and real estate developments have been sought and strengthened by private groups and civic-minded public authoritites since colonial days in the United States. Land, because of its fixity in location, is peculiarly subject to environmental influence that make or break the value of a site. This value interdependence of one site or location on another has caused individuals directly, and groups collectively, through community action to establish safeguards and control over current land uses and future land use patterns. Although effective land use control is brought about in many communities and even in large rural areas by mutual consent, by formal agreement among large tract owners, or by pressure on, or moral suasion of, individual users, principal reliance to assure proper land uses and real estate developments is placed today upon direct or indirect public (governmental) controls and upon private, contractual, and legally enforceable land use regulations.

The means for controlling and regulating land use may be grouped as follows:

Direct Public Ownership

Streets and highways (usually)
Public parks and recreations centers
Public buildings and civic centers
Public (government-owned) housing

Public Land Use Controls

City, urban, state, and regional planning
Zoning and subdivision ordinances
Building codes and housing regulations
Housing subsidies and mortgage loan facilities
Taxation and assessments

Private Land Use Restrictions

Deed restrictions
Lease restrictions
Contract limitations

The application of these land use restrictions will be treated more fully in subsequent discussions.

Land Use and the Environment

While solar energy equipment is not completely free of adverse environmental effects, providing energy from sunlight will have a much smaller environmental impact than conventional sources providing equivalent amounts of energy. Solar energy may provide an opportunity to expand population and increase industrial capacity in areas where such growth may be constrained by the Clean Air Act.

Large-scale conversion to the direct combustion of coal will make it difficult to maintain current levels of air quality unless solar energy, or some other nonpolluting energy source, is introduced to reduce the demand for energy from fossil sources. The use of solar energy can also reduce the net releases of carbon dioxide. The significance of this depends on the extent to which greatly increased carbon dioxide releases could adversely affect world climates--and this is not well understood now.

The primary environmental effect of utilizing onsite solar energy will be reduction of potential adverse environmental effects associated other energy sources. The negative environmental effects of solar energy devices stem primarily from two sources:

1. Land-use requirements, which could compete with other, more attractive uses of land near populated areas.

2. Emissions associated with the mining and manufacture of the materials used to manufacture solar equipment (e.g., manufactured steel, glass, aluminum, etc.).

Analysis shows, however, that the reduction in emissions attributable to operating a solar facility instead of a conventional one can equal the extra emissions associated with the manufacture of the solar device in 3 to 9 months.

Land for solar power generation will become of increasing concern and value since large acreage relatively close to urban or industrial developments will be required. Of course, there are all sizes of solar installations that will be built, and small capacity ones do not have the same requirements as large ones. For that reason, the criteria for land assessment are dependent on the most likely solar use.

The geographical location of the land is the second most important consideration to make for construction of a large-size solar installation. (The first consideration is, "is it possible that the deployment of capital to such an installation can be justified by financial returns?") If the economics are favorable, then one must determine if a suitable location exists and if it can be purchased. The most important criteria in selecting favorable land geography are summarized below:

A. Land should be sufficiently remote to assure that installations will not be a nuisance or danger to:

    1. Neighbors or involuntary viewers.
    2. Persons at recreational areas
    3. Motorists on highways or roads
    4. Boats or ships
    5. Aviation

B. Land should not be in the earthquake belt or near seismic faults.

C. Land should be flat or sloping to the true south.

D. Land must be incapable of being shaded by land to the west, south, and east for a minimum of eight midsolar hours each day.

E. Land must be free of meaningful growth or else be capable legally and physically of being cleared.

F. Land used for this purpose should be free of extraordinary critical review.

G. Easements, leases, rights of any kind must not interfere with deployment of collectors, et al.

H. Security must be attainable to prevent sabotage to equipment and injury to persons.

I. Sufficient land; allowing at least 7 acres per megawatt.

J. Sufficient land must be available should expansion be necessary.

K. Land should not be closer than 10-20 miles of present or planned substantial metropolitan development.

L. Location should be within 30 miles of extensive machine shop and equipment supply businesses.

M. There should be sufficient skilled construction help within 30 miles of the site, and living accomodations within 30 miles.

N. Depending on the type of collector and absorber used, a one mile "nc man's land" may be required on one or more sides of the installation for safety.

A solar plant of any size likely will have reflectors or mirrors of some sort as well as an absorber. Mirrors, when being moved, will cast the solar rays miles away. The reflections can be a danger and at least a nuisance to people and animals. There is a possibility and almost a certainty of serious and lethal radiation damage if a number of mirrors were inadvertently focused on a person, gathering, building or objects of any kind. The energy of the sun can be directed miles away without diminishing its intensity. Most authorities agree concentrated radiant energy is far more dangerous than high voltage electricity. Particular care should be exercised in making sure that federal airways and airport approach areas are free from the possibility of accidental, man-directed solar radiation.

To give some meaningful realization of size to the solar requirements for land, the average steam plant in the United States is about 350 Mw and the largest steam plant about 2500 Mw. Most giant solar plants will probably be from 150 to 300 Mw which means they will occupy from 1000 to 2000 acres of land. However, smaller communities needing 3 to 5 Mw will require only 50 acres or so of land. A 5 Mw plant is about right for 1000 to 1500 people.

The land-use impact of onsite solar equipment can be less serious than the problems associated with isolated solar equipment, since in most cases the onsite equipment can be integrated into buildings or local landscapes and extensive transmission facilities are not required. If additional surface area is required, however, lack of suitable land close to populated areas could place major constraints on the use of onsite solar equipment.

Sunrights

Guaranteed access to sunlight is currently an important aspect of solar energy market economics due to its potential impact on sales and use of solar collection equipment. The legal ramifications of solar rights have only recently begun to be reviewed by the courts, but have already been the subjects of symposia, workshops, and articles in numerous journals. The courts will not have long to wait, since lawsuits are threatened against a proposed San Diego, California, ordinance which would require the installation of solar water heaters in new homes (according to Solar Energy Intelligence Report, June 11, 1979).

The rights which one landowner may have in the land of another includes one which pertains to light, air and view. The doctrine of ancient lights gave the owner of land, by an uninterrupted enjoyment for twenty years, a cause of action against an adjoining landowner who erected any structure which interfered with his light and air. This doctrine has been almost unanimously repudiated in the United States. As a general rule, therefore, the owner of land has no legal right to the light, air, and view from the adjoining land. It can only be acquired by an express grant. A few states have enacted statutes to the effect that a landowner shall not erect any structure on his land, although otherwise lawful, if he does it maliciously and with the intent to injure his neighbor. In the absence of statute or an express grant, however, a landowner is not liable to his adjoining landowner for the maintenance or erection of structures on his own land even though they result in cutting off the light and air coming laterally from the land on which they are erected.

The legal status of solar access, or a property owner's right to receive unimpeded sunlight from all parts of the sky, is becoming a point of some interest to designers, manufacturers and buyers of solar collection equipment. If the solar industry is to penetrate a cautious market, solar access needs reinformcement of a kind that will instill confidence in buyers' minds. Assurance is needed that their active collection equipment or passive architectural design features will not be reduced in value by construction or tree planting that occludes the sun. Banks and lending institutions, including the government, will be wary of financing solar collector plants that might be shaded before their useful lifetimes have expired. And it may also be considered within the national interest to ensure that investments in fossil-fuel saving apparatus and design techniques are encouraged and protected.

The power of Congress to exert federal control over the question of solar access may be construed from past activity under the Commerce Clause of the Constitution. Under this broadly interpreted clause, Congress is empowered to regulate interstate commerce and any activities which significantly affect that commerce. Because the sale and use of solar collection equipment is projected to have an impact on the interstate sale of electrical energy and compete with all forms of fossil fuel currently traded between states, solar access appears to be an issue for consideration by Congress. However, given the activity of state legislatures in this area, some of which have already moved to institute solar rights, the necessity and wisdom of federal action has been questioned, and it seems unlikely that Congress will need to act at all. Already, the passage of the Solar Energy Research, Development and Demonstration Act and the Solar Heating and Cooling Demonstration Act in 1974, and the more recent passage of The Energy Act of 1978, constitute a major statement of intent on the part of the federal government to protect and encourage solar energy usage.

Various methods have been proposed for the creation and implementation of rights to solar access. In order for legislative action to effectively guide judicial enforcement of solar rights, many ambiguities that now complicate the concept must be removed. For instance:

1. Should a property owner be entitled to full sunlight over the entire area of his lot, or should he be guaranteed only the light falling on the walls of his house, the roof alone, or only portions of the roof bearing collection equipment?

2. Is it necessary that solar access be guaranteed from sunrise to sunset, or can shading be allowed at certain times of the day over limited parts of a home or collector?

3. Should rules of solar access vary over the seasons as the solar azimuth and elevation vary?

These questions are important if passive architectural features are to be protected as well as active roof top or detached systems. Differences in collector design suggest the need for different regulations. A fixed flat-plate or trough collector has a fixed "window" through which it receives sunlight, while a tracking collector has a constantly moving one. Fractional shading of a large flat plate assembly may not affect overall performance greatly, while partial shading of a narrowly focused parabolic concentrator may greatly reduce its efficiency. The law will have to take notice of these variables.

A considerable amount of protection can be provided, however, with imaginative use of existing laws, zoning ordinances, and covenants.

Easements

An easement is the right to use the land of another for certain purposes. Some examples are party driveways, party walks, the right-of-way for ingress and egress over another's land, the right to maintain windows for light and air, and the right of drainage across another's property. Easements are of two kinds: the easement appurtenant and the easement in gross.

An easement appurtenant is a right acquired by the owner of one parcel of land to use the adjacent land of another for a special purpose. This type of easement always requires two parcels of land owned by different persons. The property benefited by the easement is known as the dominant estate, the property that is subject to the easement is known as the servient estate. An easement appurtenant runs with the land and the benefits pass to subsequent grantees of the dominant estate, whether mentioned in the deed or not.

An easement in gross is the right to use the land of another without the existence or necessity of an adjacent or dominant estate. An easement in gross is a personal right and does not run with the land. Illustrations are easements to place billboards, signs, or right-of-way for private or public utility installations. The owner of an easement in gross need not, and as a rule does not, own adjacent property.

An easement may be affirmative or negative. An easement which gives the dominant tenement a right of way across the land of the servient tenement is a good illustration of affirmative easement. An easement which gives the dominant tenement the right to prevent the servient tenement from erecting a structure which would cut off light, air, or view of the dominant tenement is a good illustration of a negative easement.

The term solar easement is generally conceived as a specific type of negative easement, or one where the owner of the servient estate is prohibited from doing something otherwise lawful upon his estate, because it will affect the dominant estate (as interrupting the light and air from the latter by building on the former). A solar easement obligates the owner of the servient estate not to obstruct the sunlight passing over his land to the dominant (solar user's) estate.

Assuring the protection of sunrights in neighborhoods can be a difficult problem. Many existing buildings in older commercial areas probably could not be adapted to use solar energy unless basically rebuilt, which means the demand for solar access in these areas may be small. Clearly, it would be desirable to consider solar access when an entire area is to be redeveloped, or even when individual permits for remodeling are issued.

Probably the strongest available techniques for protecting sunrights in existing developments is the purchase of solar easements. It may be possible (for a price) for a prospective solar owner to purchase an easement that will require his southern neighbor to cut trees to provide access to sunlight. Such easements for light might be feasible in rural or residential neighborhoods, but they certainly are not in urban areas because the cost of the easement would nearly equal the value of the entire property.

Easements are created as follows:

1. Express grant: A formal and written agreement is drawn between the parties or owners of land; this agreement is generally recorded.
2. Implication or necessity: Courts will support implied reservations or easements where the intent is clear or where the easement is strictly necessary to provide access to dominant land, to support adjoining buildings, partition walls, or for party driveways.
3. Prescription: This right or easement is acquired by open, exclusive, and continued use over a period of time, varying from ten to twenty years, depending on applicable statutory or common state law. Prescriptive rights cannot be acquired against property of the federal or state governments or against owners who are under any kind of legal disability, such as infants or insane persons.

Where the authority does not already exist for establishing solar easements, state legislation can standarize procedure and notify the public of the mechanism's existence.

Express Easements

Express easements provide a private legal device to protect access to sunlight in both new and existing developments. A property owner, concerned about shading, could bargain with a neighbor for an unimpeded path of sunlight over the neighbor's land. Easements, which may also be leased, are binding on subsequent owners of both parcels in many states, but in others new legislation may be necessary to assure continuity of access to sunlight. Something of value is traditionally given in exchange for land (although some courts don't require it), and the agreement must be in writing to be enforceable.

The use of express easements to ensure solar access avoids the expense of public acquisition, places the responsibility of action only on interested individuals, and makes a more permanent insurance than zoning laws, which are susceptible to amendment. The major advantage of the express easement is that highly motivated individuals can usually obtain one through their own efforts without governmental action. Furthermore, express easements are site-specific and adaptable to individual preferences and bargaining. In addition, the express easement would provide security in many established neighborhoods as well as in new ones. Even if solar zoning laws are passed, property owners may want to negotiate express easements because (1) they want more protection that is afforded by the zoning law, or (2) they want a guarantee of permanence not found in easily changed zoning laws.

There are limits to the usefulness of express easements:

1. They are voluntary, courts cannot force their creation.

2. They may be prohibitively expensive.

3. They place the cost of solar access on the solar energy user, who already has the burden of large capital investment to confront.

4. The expense of enforcing the new easements in court is uncertain; their enforcement may involve long, costly court proceedings.

5. They may give an unjustified windfall to an owner or "burdened" property who never had any intention of using the property in a manner that would block sunlight.

6. Because express easements can be considered property, they can be leased as well as taxed.

Public policy may suggest that the cost should be shared or that the builders of the interfering structures should pay solar equipment owners for their "resource" (solar energy) rights. Ancillary legislation may be required to control leasing rates and hopefully to eliminate taxes altogether.

If a State views easements for light and air as benefiting a person (i.e., "in gross") rather than a parcel of land, the State may not enforce the agreements against subsequent owners, although a subsequent owner probably could. To attain enforcement, a State can enact a short, simple statute stating that such easements must include the vertical and horizontal angles over adjoining property; terms and condition of the grant; and any compensation to be paid to any party involved. The legislation should also assure the recording of express solar easements along with other land records. Some states have already enacted such legislation, and others are considering nearly identical bills.

Implied Easements

An implied easement is one thought to be necessary for the reasonable use of a property, such as the use of a pathway for access to and from a building. It differs from an express easement in that is need not be written but is assumed from the circumstances. An example of such an easement of relevance to the subject of solar access is the right recognized in all the states of a property abutting a public street to light, air, and view from that street. Litigation over the loss of these rights arose first in urban areas when level and overground railroads were constructed, resulting in the shading of street front property. Both lower courts and the Supreme Court have upheld suits against the taking of these rights and have found such takings to be compensable.

There are three dominant characteristics of the implied easement:

1. The easement is considered a property right, or property in itself.

2. The monetary value of the easement can be determined.

3. The easement can be sold and conveyed in cases on condemnation under the power of eminent domain. (Eminent domain is the right of a government, or quasi-governmental agency, to take private property for public uses or purposes upon payment of reasonable or just compensation and without the consent of the owner.)

One suggested method for instituting solar rights is the legislative creation of universal easements to solar energy similar to those now existing for street front properties. This enactment would be followed by public acquisition, through eminent domain, of these easements, making the protection of solar access defensible in the method already established for "light, air, and view". Its outstanding advantages are that it would provide immediate and uniform protection and could be incorporated into existing land-use control agencies. The primary disadvantages of the public acquisition proposal are its administrative complexity and its large cost to the public.

Prescriptive Rights

An activity that has been exercised from time immemorial (or for some period stated in law) can become established in law and is called a *prescriptive right*. The "doctrine of ancient lights", resurrected in most discussions of solar access, is a provision of English common law which states that if light, air, and view have been enjoyed from a window for more than twenty years, the right to those amenities becomes "absolute and indefeasible", a right by prescription. Problems with interpretation of the doctrine and its treatment in American courts have led most commentators to the conclusion that a grant of solar rights based purely on prescription would never pass judicial muster in this country.

The case of *Parker versus Foote* in 1838 is generally cited as the reason for the doctrine's abandonment in American jurisprudence. In that New York case, a suit was brought in objection to the obstruction of light falling on one property by the construction of a building on another. In a decision that was as much a statement of public policy as law, the court found the doctrine inapplicable to contemporary economic conditions and stated that upholding it would unfairly stifle urban development.

More recently, the doctrine was rejected in Fontainbleu Hotel Corporation versus Forty-five Twenty-five Incorporated. In this case, the Fontainbleu Hotel in Miami, Florida, sued the owners of the Eden Roc Hotel to the south when the latter built an extension which shaded the Fontainbleu swimming pool after 2:00 in the afternoon. The court cited the judicial history of the ancient lights doctrine in its decision, concluding that "in the absence of some contractual or statutory obligation, a landowner has no legal right to the free flow flow of light and air across the adjoining land of his neighbor". The court went on to say that the proper method for en uring against shading was a specific amendment of the planning and zoning ordinances of the city.

Though the doctrine is still in force in other parts of the English-speaking world, it has been lost to American law. In English law, the doctrine has traditionally been applied to "solar light" rather than "solar energy". Were it not for other disadvantages, a redefinition might have made the doctrine useful in this country. However, many drawbacks make prescriptive solar rights impractical. First, there is the question of lead time before the right is established. Ten to twenty years may be too long a period to offer any protection against shading, yet "retroactive" prescription would be objected to in many cases as constituting an unfair burden on servient property holders. In general, prescriptive rights are seen to be too inflexible to be successfully applied for insuring solar access.

Restrictive Covenants

The numerous local building covenants and architectural review boards provide another opportunity for protecting sunrights in a community, but may also present problems for solar equipment. There are two legal terms that mean almost the same thing: "restrictive covenants" and "equitable servitudes". A covenant is simply a promise involving land. It is usually found in a deed and frequently controls esthetics, i.e., the appearance of property. Esthetics may also be controlled by laws and ordinances, but private controls are more common.

In practice, today, private promises are enforced as equitable servitudes, rather than as restrictive covenants. This is because money damages are usually less satisfactory than an injunction and because of the complicated ancient laws regarding covenants.

Covenants are of greatest potential use where new tracts are opened for development (they will be of almost no help in established neighborhoods). Subdivision developers realize that some homogeneity in a neighborhood will appeal to potential buyers. For instance, covenants may require shrub and tree plantings to conform to a general landscape plan. In large subdivisions, covenants could be incorporated that guarantee access to solar energy for home heating and cooling. They could be worded like a solar easement, or could specify generous setback requirements and strict height limits on trees and structures. Large-scale developments could be required to provide such agreements.

Restrictive covenants are included (or incorporated by reference) in every deed when individual lots are sold, and are also enforceable against future purchasers. The owner of a lot in the subdivision who would be harmed by a neighbor's breach of a covenant has standing to sue the neighbor, despite the lack of direct participation in the contract.

Covenants to protect solar access can be routinely used in subdivision, mall, or industrial park situations. They cost nothing, and do not require unsophisticated individual property owners to draw up legal documents. The developer's lawyer has only to add a clause or two to the deeds.

Restrictive covenants could be used to hinder solar homes as well as encourage them, since they are used to create private architectural review committees with authority to reject changes in building appearance. This authority is often stated in extremely general terms, and could be exercised to prohibit use of a solar collector. The most likely course of relief against a recalcitrant board will be to seek declaratory relief in court, i.e., a statement from the court that the covenant is unenforceable, because it is not clearly and unequivocally expressed. Because the law on this subject is "highly technical, erratic, and in flux", the outcome of such challenges will be difficult to predict.

There is little question that a city could prohibit new covenants among private parties that unduly interfere with the use of solar collectors. The enforcement of existing private covenants can also be affected by changes in zoning in some cases. Generally, the more restrictive provision will govern. But zoning can influence a court in determining whether to invalidate a restrictive covenant because of changing conditions. In a few states, courts have gone substantially further and created a rebuttable presumption that the zoning change reflects changed conditions. Thus, a zoning ordinance defining areas in which use of solar energy is expressly encouraged might convince some courts that the review board must allow for use of solar collectors.

Land-Use Planning and Controls

Commonly used techniques that could promote solar utilization in new developments include comprehensive city or county plans, energy impact statements, and flexible zoning techniques. Imaginative work is needed to determine how best to use existing laws. Although local governments are able to help protect sunrights, under existing statutes this power usually is not used to help solar equipment owners. Many solar access conflicts may arise because the value of solar energy was not considered at the design stage. For example, the placement of a building on a lot may determine whether neighboring buildings are shaded.

Many existing controls on construction and land use might be used, with slight modification, to provide for the timely consideration of solar access. Several states--including Arizona, New Mexico, and Virginia--have information and promotional activities that could include educating builders about design criteria for solar energy. A bill in Oregon suggests a more aggressive approach; the extension service program is directed to use county extension agents to disseminate information about solar energy. A similar measure has been proposed at the federal level.

Land-use patterns appropriate to solar energy may not coincide with other methods to conserve energy. For instance, dispersed development is essential to some methods of utilizing solar energy. If lots are very large relative to the structures on them, neighbors will not shade one another. But such spread-out development means more fuel must be burned for transportation. Communities should be interested in minimizing total demand for nonrenewable fuels.

A holistic approach is suggested by an ordinance adopted in Davis, California. A more traditional approach is to require consideration of energy conservation objectives in comprehensive plans. Comprehensive plans are used in many states to guide long-range policy in local zoning. A growing minority of states require localities to adopt comprehensive land-use plans that conform to standards set by the state. Oregon, for example, requires that energy conservation be included as a goal in all local plans. Provision for solar energy in comprehensive plans was suggested by the American Bar Foundation, and has so far been considered in at least two states.

Solar Access and Zoning Ordinances

The power to zone can literally shape a community from broad outline to minute detail. In 1924, Congress drafted a Standard States Zoning Enabling Act. This exemplary Act, or modifications of it, was adopted by most state governments, and empowered municipalities desirous of this form of land use control to draft and implement zoning ordinances. Since that time, zoning and subdivision ordinances have been designed that regulate such aspects of community design as homogenous land use zones, street width, lot size and setback requirements for buildings and fences. Architectural features such as roofing materials, maximum building height, and permissible outbuilding design are also regulated in many ordinances. More recently, regulations have been developed that limit construction of new housing units by yearly quotas, require construction to be compatible with terrain to prevent soil erosion, and allow higher than average residential density in exchange for donations of land to be preserved as open space. The constitutional issues surrounding the "taking" of perperty rights by such land use controls have been extensively argued in the courts, and the function of planning and zoning boards is a familiar aspect of American urban government. In these respects, zoning has already accomplished many of the tasks a novel approach to solar access would have to undertake afresh.

Although enabling legislation for zoning and some form of subdivision control exists in all 50 states, one expert estimates that only 5000 out of 60,000 jurisdictions with power over land use exercised zoning powers in 1974. Existing authority to plan for solar energy may therefore be adequate but not in and of itself sufficient to solve the problem.

Zoning law can both facilitate and frustrate the collection of solar energy for heating and cooling structures. Relevant factors controlled by zoning include height, setback, and sideyard restrictions; percentage of lot area covered; use and accessory use; esthetics; structural orientation; etc. For instance, in residential areas only one accessory structure is often allowed, a regulation that rules out a detached collector if a garage or tool shed already exists.

Several modifications could be made to existing zoning ordinances to protect solar access. Street layout along east-west lines could be stipulated, affording property southern orientation of adjoining lots. Similar requirements for roof orientation would allow retrofitting of solar equipment in later years. Setback regulations forcing the placement of buildings near the northern lot boundaries would reduce the problems of shadows cast from the south. Height restrictions could be defined more specifically to control the shadows cast by buildings. Most proposals for mandatory solar zoning are limited to areas zoned for single-family houses, provide for some sort of administrative appeal to relieve undue hardships, and would be enforced like regular zoning laws. Some give all homeowners sun rights; others use a first-in-time-wins approach.

A significant advantage of the zoning approach is that each municipality drafts its own regulations, enabling the regional flexibility needed to accomodate local solar geometry. The familiar political climate of the city planning department may also be more favorable than a state agency for the implementation and protection of solar access. A zoning ordinance incorporating many of the modifications noted above has been adopted in Albuquerque, New Mexico, and has received much attention in the literature.

Despite the adaptability of zoning regulations, there are criticisms of this approach. Disadvantages inherent to approaches based on zoning include:

1. Zoning boards are notoriously susceptible to local politics and special interest group and often grant or refuse variances almost on whim.
2. It would be very expensive for a state or locality to intelligently redesign zoning plans.
3. It can be expensive and difficult to appeal zoning decisions.
4. If there are no restictions in the enabling legislation, zoning laws can typically be changed by only three readings by relevant local authority.
5. Blanket zoning for solar access may conflict with other energy-conserving techniques: compact, contiguous development, for example, cuts the amount of fossil fuels needed for heating and cooling structures and for transportation.
6. Expertise in planning boards for solar applications is lacking even in vigorous and up-to-date planning agencies.
7. New zoning ordinances will not have any effect on existing neighborhoods, so other methods of assuring solar access will still be needed.
8. Currently, zoning ordinances in many areas are an impediment to the use of solar equipment and will have to be altered.
9. Specifications outlawing the use of private property for the production of power, certain types of nonconforming structures (such as detached collectors), or novel roofing materials will need modification.
10. Orientation of streets and buidlings to expedite passive collection or retrofitting of collection equipment may conflict with landscaping necessary to reduce soil erosion, rainwater runoff, or noise.

Ensuring solar access is fundamentally a question of land use, specifically, activity on the land which might inhibit surrounding properties' sunlight. Zoning and subdivision law has evolved for the express purpose of regulating land use to promote the public health and well-being. For this reason, some commentators view zoning as the most suitable device for guaranteeing solar access.

Zoning For Esthetic Purposes

Private, esthetic controls are contained in the form of prescriptive easements, however, there are public regulations for estehtic purposes, and possible remedies are needed where such regulations could obstruct solar energy development. A right to sunlight falling on a roof is of little use unless the owner also has a right to put collectors on the roof to receive it.

Judicial consideration of esthetics regulation has a long, complicated history. The majority of courts, until quite recently, were very reluctant to support regulation solely for esthetic purposes because of the inherently subjective nature of esthetic judgments. In many cases, esthetic values are joined with some other more acceptable public purpose, such as maintenance of property values. This is particularly true where regulations seek to preserve areas attractive to tourists for their scenic or architectural beauty, such as in Santa Fe, New Mexico, and New Orleans, Louisiana. Courts usually uphold archetectural controls under these narrow circumstances.

Another judicial approach to esthetics regulations is what may be termed the "least common denominator test". Under this view, some land uses are so obviously discordant and disruptive that they clearly fall within the scope of permissible government regulation. Presumably, solar collectors would not come under this test.

A few states, including New York, Oregon, Massachusetts, and Wisconsin, have discarded all pretenses and upheld regulation for purely esthetic purposes. The most recent major opinion in this area, characterized as "the modern trend in the law" that "esthetics alone may justify the exercise of the police power".

In contrast to the trend in favor of architectural controls and restrictions on billboards, several courts have recently held ordinances invalid that required homeowners to keep grass and weeds below a specified height. These cases have been reported in the press, but are not yet published. The implication is that courts may apply a balancing test to restrictions on the appearance of property, rather than the traditional (more lenient) standard of reasonableness applied to zoning. If the property owner can assert some valid interest in the challenged use (appearance), courts may invalidate the ordinance even under the "modern view".

Solar systems need not be ugly. One prominent solar engineer stated recently...."so long as the structure is still on the drawing board, I feel solar can be adapted to any architectural style... We've designed applications from everything from salt boxes to contemporary designs to mountain cabins to a bank".

Flexible Zoning Techniques

Flexible zoning techniques include planned unit developments (PUD's) and bonus or incentive zoning. Only a few States specifically authorize PUD's, but some communities use this technique without State authorization. PUD's minimize zoning restrcitions and allow developers to propose a layout, building design, and uses, all as one package. Often the local ordinance provides some criteria, but review of the site plan is performed through a flexible, case-by-case procedure. PUD's are flexible enough to incorporate any design objective, including solar access. Developers could be required to indicate the impact of shadows in their proposals and to justify any significant lack of solar access.

Other flexible zoning techniques that provide governmental rewards in return for the developer's attainment of specified objectives also may be applicable. This type of zoning, generally referred to as "incentive" or "bonus" zoning, is most appropriate when the public benefit could not be obtained directly by police power regulation. For example, a Milwaukee ordinance allows increased floor area in exchange for adding plazas, arcades, and other open space around office buildings. This approach might be appropriate to encourage provisions for solar access in high-density areas.

Transferable Development Rights

An innovative concept that is much discussed but that has received little actual application is transferable development rights (TDR). The development rights of any lot are governed by zoning laws that specify allowable heights, densities, setbacks, etc. To "transfer" such rights, the government must allow them to be sold separately from the land. What is sold is not air rights, but a governmental license to build. Everyone in an area could be given equal development rights, but may not be allowed to fully use them (by erecting a big or tall building) because of solar skyspace easements acquired by the municipality through condemnation or zoning. In other words, a specific governmental restriction would be imposed within a general, less limiting governmental restriction. Under a TDR approach, the restricted property owners would be allowed to sell any development rights that they could not use to owners of property zoned for more dense development. In effect, the government takes away with one hand what it gives back with the other.

TDR has been sparingly used to preserve unique historical sites and environmentally critical areas. It may have some limited applications to solar access planning. John Costonis, who helped develop the concept of TDR, has said: "It is conceivable that if we hold density down substantially in an area to prevent interference with the sun's rays, we may create a situation of basic inequity among landowners within that area. This TDR scheme may provide a basis for permitting a landowner not permitted to achieve certain densities to receive the cash equivalent for his loss".

TDR may help avoid an unconstitutional taking where the development on one lot is severely restricted for the benefit of another. Even if an unconstitutional taking is not involved, the public's sense of fair treatment may demand that TDR or some other form of compensation be applied. To conclude, TDR is a very complex approach with dramatic side effects. It probably should not be used just to secure solar access, but may have an appropriate role as part of a comprehensive land-use plan.

Energy Impact Statements

Another approach that avoids direct regulation, but shifts more of the burden to the builder, is the use of an energy impact statement requirement. Since federal adoption of the National Environmental Policy Act in 1969, more than half the states and many localities have adopted requirements for environmental impact statements in some form. Nine states explicitly require that impact statements discuss the effect of projects on the consumption of energy; two have specifically required discussion of energy conservation.

Since large land developments will come under the impact statement requirement in most states, this procedure might be used to assure consideration of solar energy utilization. A bill in Colorado would require subdivisiion regulations to include standards and technical procedures for solar energy use. The builder would also have to demonstrate energy-efficient design, e.g., proper orientation of the structure to minimize energy consumption.

Nuisance Laws

Nuisance is a class of wrongs falling within the law of torts, i.e., the law of torts pertains to civil wrongs. The word "nuisance" denotes that class of wrongs arising from an unwarranted use of property lawfully occupied by one person which restricts the ordinary use of property lawfully occupied by another person. It is practically impossible to enumerate the various unwarranted uses of property that may be classified as nuisances. Moreover, what constitutes a nuisance at a particular time and place may not constitute a nuisance at another time and place. Loud and boisterous noises, for example, shouting and singing, especially at nighttime, may be a nuisance. The pollution of air with noxious fumes, gases, vapors, smoke, and soot may be a nuisance. A business enterprise and occupation, although lawful in itself, may be a nuisance. When the question of a nuisance arises, the courts are frequently confronted by the problem of striking a balance between the interests of the private-property owner and those of a growing industry.

By declaring the shading of solar equipment a public nuisance, jurisdictions could grant solar energy users protection similar to that offered by public acquisition of solar easements, injunction to halt shading, or compensation for energy lost. Although this solution requires a relatively simple legislative statement, its efficancy has been questioned. Following such a legislative declaration, lawsuits may still be required to prove nuisance in individual cases, property owners burdened by nuisance restrictions may demand compensation, and suits brought to protect solar access before collectors have been installed may be dismissed as premature. Injunctive relief, which would require offenders to halt any shading activity is not likely to be awarded in most cases. Moreover, only a public official may bring suit to enforce such a statute, unless the language of the statute provides specifically for attack by an individual. Otherwise, if an individual is to bring suit he must prove damage different in kind, rather than degree, of the public damage.

Private nuisance law is largely ignored in the literature. However, one small town, Kiowa, Colorado, has passed a zoning ordinance allowing a property owner with a solar collector to have a structure declared a public nuisance if it interferes with the owner's collector.

Even where legally possible, there are disadvantages to protecting solar access with a statutory public nuisance approach:

1. Lawsuits would be necessary to prove each instance of a nuisnace.

2. In some cases, the owners of restricted property may truly deserve compensation, but no compensation may be available.

3. Injunctive relief would not be available in many jurisdictions.

4. If one tried to sue before going to the expense of installing a collector, the suit may be dismissed as not "ripe".

5. Since a public nuisance is a crime, a homeowner may have to wait for the state to sue. Under some circumstances, however, private individuals may sue if they can show they were particularly damaged, in some way not shared by the public generally. The plaintiff's damage must be different in kind, rather than just degree, from the general public's. It is uncertain whether shadows cast on a collector would meet this requirement. It is possible that a statute could get around this problem by stating that individual citizens may sue in the public interest.

6. A ticklish situation would arise if a bungalow owner living between two skyscrapers decided to put collectors on the roof. The majority view is that the person who in good faith comes to an existing public nuisance has rights to have it abated--even though it was there long before he arrived.

Just as nuisance laws will not be of great help to solar homeowners, they will not help those protecting solar homes. It is unlikely that a solar collector would be found to be either a public or private nuisance as "the mere unsightliness of defendant's premises" is usually insufficient to create a nuisnace".

Water Rights Law

By incorporating the principles of solar geometry into zoning ordinances or express easements, the body of experience already established in the law could be used to implement the novel concept of guaranteed solar access. By making an analogy between sunlight and some other natural resource with a proven history in law, another vehicle could be developed. Oil and gas law is a possibility, but its emphasis on ownership, complex leasing arrangements, and the exploitation of finite areas and quantities are not characteristics shared with solar energy. Because solar energy is used, not extracted for sale, and because its availability is not diminished by use, water is a better analogy for sunlight.

American water law is divided into two schools of theory. In many of the moist states, the doctrine of riparian rights is followed. Here, the right to use water flowing in a stream is incidental to the ownership of land abutting the stream. In drier western states, rights to water are apportioned according to the doctrine of prior appropriation, where right is established on the basis of who first extracted the waters for a beneficial use. For a number of reasons, including a weaker judicial history, lack of flexibility, and administrative disfavor, the riparian doctrine has been passed over in favor of the prior appropriation system.

Mary D. White proposed a controversial state-level approach for solar access rights in 1976. She suggested allocating sunlight as water is allocated in states that use the prior appropriation doctrine. The proposal has several advantages:

1. It provides an equitable framework for the allotment of solar rights without great public expense or complex administration, as might be required under zoning and public acquisition of solar easement schemes.

2. Those who want assurance of solar access can apply for it; those who don't are not affected by the system in any way.

3. The system provides for the assessment of individual cases in an equitable, efficient, and inexpensive manner; except in cases of re-hearing or appeal, a lawyer's assistance would not be required by applicants or those in opposition.

On the other hand, under the prior appropriation doctrine of water rights, the water must be put to a beneficial use within a reasonable time and defining "beneficial use" is the subject of much water law. White identifies the real question as whether a beneficial solar use would be preferred over a nonsolar use. For example, could the owner of an existing solar house enjoin construction of a conventionally heated but economically valuable structure that would shade the solar house's collector? Under the water-law analogy the newcomer would have to buy the solar homeowner's resource rights. The disadvantages of the water-right system may be:

1. The approach is grounded on the principle of "first-come, first-served".

2. It seems unfair to allot sun rights on this basis when it may be possible to plan additions to structures so that they do not shade their neighbors.

3. The application of a water-law analogy would drastically increase the value of some parcels, while slashing the worth of lots to their north. Such unequal treatment may be unconstitutional, since no compensation would be paid for lost development rights.

4. It seems unreasonable to force property owners to install solar equipment prematurely just to protect their sun rights. Conversely, under a water-law analogy, property owners may have to build additions to their structures prematurely if their neighbors hint they may install solar equipment.

5. Substantial conflict with land-use planning goals is possible.

6. Many more people would seek solar rights than presently file for a permit or go to court to secure water rights. Conceivably, nearly every property owner in the United States could try at some time to secure solar rights. In states like Colorado, where court proceedings are necessary, courts could be overwhelmed.

Although the approach is controversial, the state of New Mexico has passed a Solar Rights Act based on the prior appropriation principle.

The New Mexico Solar Rights Act

During the 1978 Legislative session, the New Mexico Solar Rights Act was passed into law. This piece of legislation acknowledges, "... that the right to use the natural resources of solar energy is a property right, the exercise of which is to be encouraged and regulated by the laws of this state..." The act further defines solar rights as "... a right to an unobstructed line-of-site path from a solar collector to the sun, which permits radiation from the sun to impinge directly on the solar collector".

In order to establish your solar right you must make "beneficial use" of the sunlight. Under this law, only those individuals who are actually using sunlight "beneficially" are protected. Unless written into a contract, potential use or future solar rights are not protected under the law. The law was passed to protect solar systems that provide significant benefit and not prohibit or impede the development of adjacent property.

According to the law, "a solar collector means any device or combination of devices or elements which rely upon sunshine as an energy source and which are capable of collecting not less than twenty-five thousand Btu's on a clear winter solstice day". To find out whether or not your solar collector complies with the definition of the law, you should consult the manufacturer's specifications or the dealer/installer from which you purchased the solar system.

The statute further notes that "the term solar collector also includes any substance or device which collects solar energy for use in: the heating or cooling of a structure or building; the heating or plumbing of water; industrial, commercial or agricultural process; or the generation of electricity." The law also states that a solar collector can serve as a structural member such as a roof, a window, or a wall. Consequently, passive solar systems or components (greenhouses, trombe walls, or direct gain systems) are protected under the law.

Not only does the law provide definitions for determining solar rights, these definitions are used as guidelines when disputes over solar rights occur. For example, if a property owner sells the property, the solar rights remain with the property. However, solar rights can be sold or eliminated completely, in which case recording of such transfer or elimination should be in accordance with Chapter 14, Article 9, NMSA 1978. Finally, if disputes over solar rights occur, the law states that the property owner(s) of the adjacent property is prevented from doing anything that would shade your collector after you have established "beneficial use", established that your collector was there first, and have filed a claim for your solar rights. It should be emphasized that in most municipalities no mechanism has been established for filing solar rights. Consequently, individuals wanting to file their solar rights should contact their county clerk's office (property records division), or the local planning/ zoning office. If litigation results, it is always wise to seek counsel.

Since there are many communities within the state which now have or will be implementing their own solar rights ordinances (Albuquerque, Las Cruces, Los Alamos, Santa Fe, Taos), it is advisable to consult the local planning or zoning authority relative to solar rights questions.

(All of the above is information directed to inform the public of the general content and nature of the New Mexico Solar Rights Act.)

Solar Energy and Insurance

The primary function of insurance is to substitute certainty for uncertainty by shifting the risk of a disastrous event to an insurance company. A payment, termed an insurance premium, is made to the company as compensation for its acceptance of the risk. A policy contract between the individual and the company stipulates the amount and term or period of time of the insurance protection. The insurance company, of course, insures many individuals against the same risk. The overall effect is to spread the cost of the disastrous event, which normally would fall on one individual, over many individuals exposed to the same hazard.

It will still be awhile before all insurance companies have evaluated the risks involved with solar equipment, and the rates they must charge to insure against those risks. Insurance companies have not been reluctant to provide insurance for solar heated structures. Comprehensive insurance has not yet become a high risk factor since glass breakage has not been excessive. Fire insurance should not be affected since the required additional insulation is fire resistant and the energy requirements (electricity for controls, etc.) are similar to those used in conventional heating components. There may be a need to have fire stops placed in the roof-to-equipment-room space where pipes are located. These air columns could act as a flue and cause a draft that would draw flames from the basement to the attic. Also, heat and smoke detectors should be installed as recommended by Underwriter's Laboratories.

On the other hand, many passive and active solar collectors are covered with sheets of glass, and make tempting targets for small children with stones. Suppose a motorist is suddenly blinded by the glare of a nearby solar collector, and has a serious and costly accident. Who is liable for the damage? What if the additional weight of the collectors on a roof cause it to sag or collapse? Is there insurance coverage available for that possibility? These and many similar questions still need answers. We know that good design and careful construction can greatly reduce the risks that might otherwise be present. But is good quality work good enough?

As solar energy commercialization expands, there will undoubtedly be legal issues raised regarding the role of insurance and the pecularities associated with solar equipment and activities. Such issues would probably fall into one of three principal categories: property losses, public liability, and workmen's compensation.

SOLAR ENERGY AND LABOR

One of the most critical issues in evaluating the impact of a new energy technology on labor, and one of the most difficult to deal with reliably, is how the technology will affect overall manpower requirements in the energy industry. Interest in solar energy applications has a history of peaks and valleys in the United States. Recently, of course, interest has accelerated to the point where the national effort in solar energy research and development probably exceeds one billion dollars a year. It is expected to reach several billion dollars soon when solar devices are more widely marketed.

The growing emphasis on solar energy applications implies future demands for a variety of manpower skills and capabilities, including research and development skills, analysis and design skills, manufacturing skills and installation and maintenance skills. Many of these skills and capabilities may be available in adequate numbers through normal reallocation of manpower resulting from private sector market forces (e.g., job openings, differential wage rates, and investment decisions). On the other hand, adequate availability of some skills may require considerable advanced planning and public sector support, particularly where rapid development and implementation of new technologies is expected. Information about needed skills and capabilities, provided through manpower surveys and forecasting, aids in the formulation of government policy and can be used in making policy decisions regarding research and development contracts, educational support, manpower training, and other programs. Manpower surveys and forecasting are especially important when anticipated manpower shortages or surpluses could act as a constraint on Federal policies or programs.

With regard to solar energy manpower, the concern is that a lack of adequately trained manpower could constrain the development and acceptance of solar energy as an alternative energy source. First, the development and application of solar may create additional employment opportunities that exceed the available manpower pool. This could be particularly true if there are new Federal initiatives in solar research and development or new incentives for commercialization. Second, the existing employment opportunity may require new skills or different mix of skills than is currently possessed by the workforce. For example, additional training in solar applications for engineers and technicians may be required.

The Impact of Solar Energy On American Labor

While the analysis of the overall labor requirements of solar energy is very primitive, it is possible to be somewhat more confident about some qualitative aspects of solar energy's impact on the work force.

Onsite solar technology appears to be more labor-intensive than contemporary techniques for supplying energy. Thus, in the short term, the introduction of solar energy devices might create jobs in trades now suffering from serious unemployment. In general, the new jobs will be distributed widely across the country and will not require laborers to live in remote or temporary construction sites because most workers should be able to find jobs in areas close to their homes. Work on solar equipment, for the most part, would necessitate only simple retraining programs, although there may be shortages both of engineers and architects qualified to design solar equipment, and of operators trained in maintenance of some of the larger and more sophisticated solar devices which have been proposed.

Assessing the long-term implication of technological development on the work force, however, cannot be reliably undertaken with contemporary economic methods. Long-term labor impacts will depend on forecasts of future growth rates both in the economy and in U. S. energy consumption--subjects about which there is great confusion and disagreement. Although making economic projections is hampered by imprecise methodology, it is possible at this point to outline some of the critical issues which concern the effects of solar energy development on labor.

Manpower Requirements

One of the most critical issues in evaluating the impact of a new technology on labor, and one of the most difficult to deal with reliably, is how the technology will affect overall manpower requirements in the energy industry. Tables VII-2 and VIII-3 compare the manpower requirements of a conventional coal-fired generating system with the manpower required to construct and to operate each of two kinds of solar devices capable of producing equivalent amounts of energy. Only first order effects have been considered, and the estimates made about solar devices are necessarily speculative. One overall conclusion seems inescapable, however; a large fraction of the value of solar equipment is attributable to direct labor costs.

The high labor intensity of solar equipment is not surprising. Most devices can be constructed from relatively inexpensive material, and the small equipment examined here would not require extensive capital-carrying charges during construction. Factories for mass production of photovoltaic devices, heat engines, and other components of solar technologies will probably employ sophisticated and expensive equipement which will reduce labor in these industries. Much of the work of installing solar equipment will continue to require direct onsite labor.

Table VII-2 lists all labor requirements for construction at the plant site, to build the 800 MWe turbine generator in a factory, to operate the generating facility at an average of 60 percent of full capacity for a period of 30 years, to build and operate a coal mine large enough to support the plant, to transport the 2.5 million tons of coal per year needed to operate the plant, and to construct and maintain a transmission and distribution network. It is noteworthy that the operating and maintenance labor is more than twice as great as the labor needed to construct the facilities, and that nearly 20 percent of the manpower requirements in operations are used to maintain the distribution facility.

Table VII-2.—Labor Requirements for a Conventional 800 MWe Coal Plant (in units of man hours per megawatt year)

	Construction	Operating and maintenance	Total
800 MWe coal plant	330	380	710
coal strip mine using western coal	20	360	380
coal preparation plant	3	290	293
coal transportation	—	340	340
electric transmission	40	5	45
electric distribution	190	310	500
steel & concrete production	10		10
turbine/generator manufacturing	170	0	170
Total	763	1685	2348

Assumptions:
- — 800 MWe coal plant operating at 60 percent peak capacity for 30 years;
- — western coal strip mine with 525-mile train line;
- — all data based on Bechtel data with the exception of the turbine generator manufacture. It was assumed that the turbine/generator cost of $150/kW of which 25 percent was labor and that this labor was paid at an average rate of $10/hr;
- — calculations divide the sum of construction manpower and 30 year operating manpower requirements by the total number of megawatt years of energy produced by the plant.

Table VII-3.—Labor Requirements of Two Types of Distributed Solar Energy Systems
(in man hours per megawatt year)

	Construction	Operating & maintenance	Total
I. Solar hot water heaters ($8m^2$ flat plate)			
—manufacture collector	800-2500	0	800-2500
—install collector.	1200	0	1200
—routine O&M	—	1200	1200
Total for hot water system*	2000-3700	1200	3200-4900
Total for hot water system including backup	2340-4040	—	3540-5240
II. Tracking silicon photovoltaic system:			
a. Electric only ($50 m^2$)			
—manufacture collector and cells	2600-3300	—	2600-3300
—install collector.	1800-4600	—	1800-4600
—operate system.	—	6800	6800
Total for tracking photovoltaic system	4400-7900	6800	11200-14700
Total for tracking photovoltaic system including backup	4740-8240	—	11540-15040
b. Electric + 0.29-Thermal (including backup).	2240-3740	3000	5240-6740
c. Electric + Thermal (including backup).	1130-1750	1240	2370-2990

Assumptions:
- — 20 year system life;
- — installation includes 75 feet of piping costing 0.11 MH/ft to install;
- — flat plates installed for 1.3 MH/m and tracking collector installed for 1.3-3.33 MH/m^2;
- — cells assumed to be 18 percent efficient, optical efficiency 80 percent.
- — labor for providing backup power is assumed to be 50% of the construction labor shown in table VII-2—(e.g., 340 man-hours/MW-year)
- — flat plates assumed to provide 930 kWh/m^2-yr (Albuquerque);

  cells provide 320 kWh/m^2-yr electric and 1450 kWh/m^2-yr thermal for PV system (Albuquerque);

  O&M labor for PV system assumed to be 0.25 hrs/m^2-yr (see table XI-7);
- — flat plate manufacturing labor based on data from several collector manufacturers;
- — concentrator manufacturing labor assumed to be .024 MH/lb of collector for PV concentrator given in table VII-7 (with concrete and sand excluded) with the labor to produce the raw materials added;

  .024 MH/lb is approximate labor input for automobile manufacturing based on employment and production for 1973 given in *1976 Statistical Abstract of the United States*, U.S. Dept. of Commerce, Bureau of the Census, pp. 369, 791.

Table VII-3 presents an estimate of the labor required to build and maintain a flat-plate solar water heating system and a small tracking photovoltaic system in Albuquerque, New Mexico. The hot water system requires 1.5 to 2.5 times more labor than the conventional coal-fired generating facility and even more if the utility must maintain a substantial facility for providing backup power. The range shown for the solar devices reflects the range of labor requirements provided by collector manufacturers. It is probable that the labor requirements of a mature solar industry will be close to the lower end of the range shown.

The major source of error in these estimates, apart from inaccuracies in data gathering, is the failure to consider the many secondary kinds of employment which could be created by both solar and conventional facilities. A significant fraction of this secondary labor would come in the manufacture of primary metals, glass, etc., for both solar and conventional systems. Given that the weight of solar devices would be equal to, or more than, the weight of conventional systems per unit output, it seems unlikely that the differences in labor requirements illustrated would be eliminated by a more-detailed analysis.

Some collector designs (e.g., plastic collectors) will almost certainly require less manufacturing labor but they will probably require more maintenance labor, while other designs which require less material (e.g., tubular designs) may require more manufacturing labor than simple flat-plate systems.

The photovoltaic system shown in table VII-3 requires more labor when only electricity is produced, because the output is about one-third that of the hot-water system. The larger operating labor results from the greater complexity of the tracking system. If the system provides thermal output as well, labor input per unit of combined output would be about one-third lower than for the hot-water system.

The labor requirements per unit of solar energy delivered would be higher in areas of the cojntry which do not receive as much sunshine as Albuquerque since each unit area of collector would produce less output.

It should also be noted that onsite systems which rely on utility systems for backup would probably not reduce the labor requirements for transmission and distribution systems significantly. This is important since a large fraction of the labor required by conventional utilities is due to these energy distribution systems. A shift toward decentralized solar energy systems could, therefore, result in replacing centralized facilities with solar units requiring greater amounts of labor while leaving the labor-intensive distribution systems intact.

Geographic Distribution

Employment in installation and operation of solar equipment can be expected to be distributed over a large part of the country. Initial installations of solar equipment are likely to occur in places with high insolation--the South and Southwest. Locations with relatively low levels of sunlight, such as the Northeast, however, tend to have high energy prices. Thus, while low insolation levels make solar energy in the North expensive, competing energy sources are also expensive, so the net economic competitiveness of solar devices may be as high in the North as in more favorable climates. Employment in installing solar energy equipment is, therefore, likely to be as geographically dispersed as the building industry.

One thing about solar employment seems clear--none of the small solar devices considered in typical analysis comparisons will require the major dislocation of a work force, or the establishment of temporary work camps as may be required for construction of a pipeline, an offshore drilling operation, or a large central generating facility in a remote location. The relatively small solar devices analyzed here will provide employment in close proximity to where workers presently live, and therefore will avoid the social disruptions associated with large influxes of temporary workers.

Unlike most major manufacturing facilities, solar manufacturing at present is spread across the country in literally hundreds of small companies. The future of these businesses, however, is very uncertain. If the demand for solar equipment increases substantially, the field may be dominated by a small number of large manufacturing firms, much as the manufacturing of conventional heating and cooling equipment is dominated by a small number of firms.

On the other hand, solar devices may be designed for special climates and sufficiently site-specific for manufacturing to remain geographically dispersed, much as facilities for manufacturing modular homes are today. It seems clear that because of the sophisticated technology employed, the manufacturing of components such as photovoltaic devices, heat engines, and concentrating devices will occur in a relatively small number of facilities.

If a major demand develops for solar energy, it is likely that employment in the area will be as stable as work in any typical building trade; the solar equipment will simply add jobs at each construction site. If a major retrofit market develops, there could also be major employment opportunities in this area; maintenance of solar equipment will also provide a stable source of jobs.

Skill Levels Required

Solar energy technology can be implemented with the technical infrastructure and cadres of skilled engineers required to implement most other energy strategies. In developing countries solar energy may provide a technique for converting low-cost labor into low-cost energy.

Most of the employment directly created by a shift to solar energy will be in installation of the equipment by the conventional building trades, and in the creation of new manufacturing industries. The skills required for installation of the equipment will be very similar to those required for conventional construction projects, although some brief training programs will undoubtedly be desirable to familiarize workers with the new equipment and its installation. Most of the work will be in framing roofs, laying footings, plumbing collectors and storage tanks, excavating trenches and pits for piperuns and storage tanks, installing sheet metal ducting, insulating pipes and tanks, and installing electronic control units. The work will be nearly identical to the installation of sophisticated air-conditioning and heating systems in conventional buildings.

Larger solar installations, such as those serving groups of buildings and large industrial operations, are likely to require supervisors, managers, draftsmen, designers, and engineers in roughly the same proportion as these skills are required in the construction of conventional power-generating facilities. In fact, since many large onsite solar facilities are likely to be supplemental to conventional boilers and generators, the solar equipment would simply add work in these areas at each installation. There may be a shortage of engineers with adequate knowledge in areas critical to onsite power in general and solar devices in particular.

Designing a reliable and efficient onsite device for a large installation (such as an apartment or industry) requires experience with other types of equipment not now conventionally used in utilities or building energy systems. Solar onsite systems require even more expertise in order to manage the added complexities of collector design, thermal storage systems, more elaborate control systems, possibly of batteries, heat engines, and photovoltaic devices.

Employment opportunities in manufacturing are more difficult to define, since the pattern of growth in the industry is presently unpredictable. Work opportunities will include glazing, metal extrusion, component assembly, and chemical processing (for photoelectric devices, select surface formation, storage systems, etc.). It is difficult to anticipate whether the employment will be created in a large number of dispersed fabricating facilities, in large central plants, or in both.

The skills required to maintain the type of simple solar equipment installed on homes and small apartments will be similar to those required for conventional appliance maintenance of utility gas and electric power equipment. Most of the personnel in these professions will require additional specialized training in solar technology. There is a serious shortage of persons with the skills needed to operate intermediate-sized solar or conventional onsite energy equipment. Owners of small total energy systems report difficulty in finding and holding persons trained in operation and maintenance of engines and heat recovery units, energy control switching, and other associated equipment. Maintenance of a sophisticated collector system will present similar problems. Many now employed in the operation of total energy systems learned the requisite skills from the U.S. military services. Such training appears difficult to obtain in private industry.

Table VII-4 and VII-5 demonstrate jobs which must now be done to support conventional electric generating equipment. The impact of solar equipment on jobs will depend on the extent to which solar devices displace fuel consumption (replacing jobs in mining with jobs in solar technologies), the extent to which the technology would cut the demand for peak generating capacity (replacing jobs in constructing and maintaining generating equipment with jobs in solar technologies), and the extent to which the need for transmission and distribution equipment would be reduced.

These effects are listed in the order of their likelihood. It is most probable that solar technology would initially affect only fuel utilization, and would affect transmission and distribution requirements only in an extreme case where all or much of local energy needs are met with solar equipment. It should not be assumed that an increase in solar utilization would necessarily replace any of the employment indicated in tables VII-4 and VII-5. The expected increase in U. S. and worldwide coal demand is likely to be so large that employment in mining would be unaffected by an expected penetration of solar energy into the market.

Several observations can be made on the basis of the tables, however:

1. Small solar installations are likely to employ more blue collar workers than professional employees.

   Solar installations on individual buildings typically require one supervisor for each 10 workmen, while the ratio for the conventional coal equipment shown in table VII-4 is closer to 1 to 3.

   The larger industrial and community solar systems would, however, require much more professional work.

2. Nearly 50 percent of the jobs associated with operating and maintaining conventional equipment is associated with coal mining and transportation.

   Jobs in these sectors could be replaced with jobs in repair and maintenance of onsite equipment.

3. About 40 percent of the work required to build a conventional electric system and 30 percent of the work required to maintain it is associated with distribution equipment, which is unlikely to be affected by solar technology.

Table VII-4.—Skills Required for Constructing a Coal-Fired Electric Generating Plant and Operating the System Over a 30-Year Period

I. Skills Required for Plant Construction (as a percentage of the 3,576 man-years required to construct the plant and the transmission and distribution network)

	Coal-Fired Electric Generating Plant	Transmission and Distribution Facilities	Total
Non-manual construction work	9% (63% engineers and 25% draftsmen and designers)	13% (50% electrical engineers, 25% draftsmen and designers)	22%
Manual construction work	49% (variety of trades)	29% (mostly electricians)	76%
Total construction work	58%	42%	100%

II. Skills Required to Operate and Maintain Equipment for a 30 year Interval (as a percentage of the 10,893 man-years required)

	Coal Mining and Coal Transport	Coal-Fired Generating Plant	Transmission and Distribution Facilities	Total
Non-manual operating work	17% (mostly trainmen)	6% (67% supervisors and managers)	3% (mostly supervisors working on distribution system)	26%
Manual operating work	42% (mostly miners and trainmen)	16% (variety of trades)	15% (mostly electricians and meter readers for distribution system)	73%
Total operating employment	59%	22%	18%	100%

*Details about assumptions used shown in Table VII-5.

SOURCE: Based on data in "Manpower, Materials, and Capital Costs for Energy-Related Facilities," Bechtel Corporation, April 1976.

Table VII-5.—Detailed Breakdown of Skills Required for Conventional Electric System* (man-years per 800 MW_e coal-fired plant and associated distribution and fuel facilities)

	Western strip mine & coal crushing & sizing plant (annual operations)	Coal transport unit train (annual operations)	Coal-Fired Elastic Generating Plant (800 MW)		Electric transmission (200 miles in length-national average)		Electric distribution		30 years of operations	Construction	Total construction & 30 years operation
			Annual Operations	Construction	Annual Operations	Construction	Annual Operations	Construction			
Non-manual workers											
1. Engineers—conductor		37							1110		1110
—civil				93	.02	12	1	81	31	186	217
—electrical	.2		4	68	.08	25	3	161	218	254	472
—mechanical	.2		2	52	.02	4		27	67	83	150
—mining	1.1								33		33
—industrial	.2								6		6
—safety	.2								6		6
—environmental	.1								3		3
Total engineers	2.0	37	6	213	.12	41	4	269	1474	523	1997
2 Designers and draftsmen	1		1	85		17		109	60	211	271
3. Supervisors and managers	14		14	40	.23	3	8	18	1087	61	1148
4 Other	8								240		240
Total nonmanual labor	25	37	21	338	.35	61	12	396	2861	795	3656
Manual workers											
1 pipefitters			8	400					240	400	640
2 pipefitter/welder			12	180			3		450	180	630
3 electrician	11		12	280	.36	133	36	843	1781	1256	3037
4 boilermaker			8	300					240	300	540
5 boilermaker/welder				100						100	100
6 iron worker				141		44				185	185
7 carpenter				140						140	140
8 equipment operators	36		20	100					1680	100	1780
9 other	68	37		120	.37		16		3641	120	3761
Total manual labor	115	37	60	1761	.73	177	55	843	8032	2781	10813
TOTAL LABOR	140	74	81	2099	1.08	236	67	1239	10893	3576	14469

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*Based on information in *Manpower, Materials, and Capital Costs for Energy Related Facilities*, John K. Hogle, et al., Bechtel Corp., for Brookhaven National Laboratory Associated Universities, Inc., Contract No. 354617-S, April 1976.

Working Conditions

Expansion of the solar energy industry should not raise serious health or occupational hazards, but some of the possible problems are discussed below. The manufacture of some photovoltaic devices employs cadmium and arsenic compounds which could present hazards to workers assembling these units. Manufacture of plexiglass and other plastics used in photovoltaic devices can also involve handling potentially harmful chemicals. These manufacturing hazards are not unique, however, because these compounds are widely used in other industries. Some steam-fitting jobs will involve high-pressure steam lines, and some proposed thermal storage methods will require very hot oils, possibly explosive or toxic. These issues deserve serious attention before such installations become commonplace. Devices using hazardous material may only be employed in larger, more centralized solar facilities and are unlikely to be found in onsite residential systems. Replacing jobs in coal mining for those in solar equipment maintenance, however, would probably result in overall improved working conditions.

Organized Labor

Organized labor is enthusiastic about solar energy's potential for creating jobs. Like many other construction trade unions, the SMWIA has a national unemployment rate of 30 percent to 35 percent, with unemployment reaching 50 percent to 60 percent in some areas of the North and Northeast (according to a 1977 private communication from B. McMonigle, SMWIA). These are regions where energy prices have risen very rapidly in recent years. It is possible that sizable near-term markets for solar equipment can be found in these areas in spite of their relatively unfavorable climates.

In 1970, the plumbers and pipefitters had a nationwide unemployment rate similar to that of the sheet metal workers. A potential labor problem associated with implementation of solar technology is the question of which union will subsume the categories of newly created jobs. Until recently there have been few solar installations so that few unions have staked out territorial prerogatives. For the most part, the solar energy field is still wide open to jurisdictional competition. The situation can be expected to change as more work in the area becomes available. An arrangement has already been negotiated between the Sheet Metal Workers and the United Association of Plumbers and Pipefitters which calls for joint crews in the installation of hot air collectors using liquid storage systems. Jurisdictional disputes could be a serious problem in other areas, however, unless all issues can be settled as amicably as this one has apparently been.

Generally, union officials feel that an upsurge of solar construction and installation would radically alter the number, not the types of jobs available to union members. Firms that now produce heating, ventilating, and air-conditioning equipment--many of them already active in solar collector construction--would simply expand their operations. Any new firms established would be unionized in conventional ways.

While labor has occasionally resisted the introduction of new technologies into the building industry, this resistance has always been directed at technologies which reduce jobs on each building site or which transferred employment from one building trade to another. The disputes associated with the introduction of plastic plumbing, prehung doors, and metal studs all resulted from one of these effects. Solar equipment would add work at each site without displacing work in other areas. It is, therefore, difficult to imagine any group with a motive to resist its entry into the market.

Long-Term Impacts

The overall impact of generating a substantial fraction of U.S. energy from small solar devices is hard to assess, since current economic theory has no satisfactory method for such analysis. None of the major price equilibrium models used to determine the future of U.S. energy supply and demand adequately treat employment issues. Most make the overwhelmingly simple assumption that there will be full employment during the entire period analyzed. As a result, many of these models tend to ignore the influence of alternative energy strategies on unemployment. The difficulties of predicting economic impacts are magnified by the lack of information necessary to translate a workable theory or model into useful policy.

In the absence of an adequate methodology, the most critical questions involving the impact of solar technologies on the work force cannot be answered with certainty. An example of one difficulty can be seen in the problems associated with interpreting the implications of labor intensity. If rapid rates of growth are expected in both the U.S. economy in general and the energy production sector in particular, and if unemployment is expected to be very low as a result, any shift to a labor-intensive technology like solar energy could prevent wages from keeping pace with growth in other sections of the economy. An industry with high labor intensity requires more manpower for the same output than industries with low labor intensity. As a result, the average wage paid per worker must be lower for the labor-intensive process. If growth is not expected to be sufficient to eliminate unemployment, labor-intensive industries will be beneficial to both labor and society by productively employing a larger fraction of the work force.

Other questions which must be addressed include:

1. To what extent would the energy produced by solar equipment displace imports, nuclear, or indigenous fuel supplies?

   To what extent will solar energy fulfill energy needs that might not otherwise be met?

   (If solar energy filled such needs, employment could grow in areas of the economy not otherwise possible.)

2. To what extent will dollar energy sources be able to reduce the need for installing additional electric generating facilities as well as reduce the demand for fuel?

3. If imports are reduced, and funds invested instead in U.S. solar industries, how much direct and indirect employment would be created?

   How much would employment be reduced in industries now benefiting from the export market stimulated by our purchase of foreign fuels?

4. What kinds of growth rates can be expected in energy sources other than solar energy?

   Will this growth rate be constrained by a shortage of capital, resources, and demand, or by a shortage of critical skills?

   Would solar energy compete directly for scarce resources or would it be able to tap ohter capital or labor supplies?

5. What kind of work force dislocations could be expected in a shift from one energy source to another?

   Would new skills not now available in the building trades be demanded?

   What kinds of transient unemployment could be expected?

Contractor Licensing and Installer Certification

The solar industry is young and many of the contractors and installers are inexperienced. This inexperience has been a significant factor in the analysis of issues relating to consumer assurance and commercialization of solar devices. There are virtually no adequate solar installer certification or contractor licensing procedures. The solar industry and solar contractors are unanimous in stating the need for certification for installers. Both groups feel that proper testing of skills or knwoledge prior to certification would lead to better installations. It would also provide a minimal level of consumer assurance.

Proper testing and certification of solar installers is a high priority action on the part of states. Proper testing of other appropriate contractor license categories for supplementary solar adjunct is also necessary. It would be appropriate for the Solar Energy Industry Association to develop a consensus certification requirement to provide to states as a model for adoption.

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CODES, LEGALITIES, CONSUMERISM, AND ECONOMICS

BUILDING CODES, STANDARDS, WARRANTIES

STUDENT MATERIAL

CODES, LEGALITIES, CONSUMERISM, AND ECONOMICS

BUILDING CODES, STANDARDS, WARRANTIES

THE BUILDING CODE ORDINANCE

Introduction To Building Codes

The planning, construction, location and use of buildings are regulated by a variety of laws enacted by local, state and federal governments. These statutes and ordinances--which include building, plumbing, electrical, and mechanical codes--are intended to protect the health, safety and general welfare of the public. Building codes establish minimum requirements for this protection. They do not necessarily contain criteria which assure efficient, convenient or adequately equipped buildings.

A building code establishes requirements for the construction and occupancy of buildings. It contains statndards of performance and specifications for materials, methods and systems. Codes also cover structural strength, fire resistance, adequate light and ventilation, and other considerations determined by the design, construction, alteration and demolition of buildings.

The Regulations: A code becomes law when it is adopted by a municipality as a public ordinance. Local communities may write their own codes or may legally adopt other codes, such as state building codes or one of the model codes described in subsequent sections. (A sample ordinance for adoption of a model code is shown in Figure 1.) All codes contain certain fundamental provisions. Following is a listing of the general provisions of a typical building code:

I. Administration and Enforcement
  A. Definitions and classifications
  B. Building limitations
  C. Use and occupancy requirements

II. Structural Requirements
  A. Footings and foundations
  B. Structural requirements for lumber, masonry steel, etc.
  C. Chimneys and flues

III. To Make The Structure Livable
  A. Heating equipment
  B. Plumbing and drainage
  C. Air conditioning and mechanical ventilation
  D. Electric wiring

IV. Health and Safety
  A. Means of egress
  B. Fire protection
  C. Light and ventilation
  D. Protection of workers and the public

V. Code Standards

Various codes elaborate on these provisions for local conditions, i.e., depth of foundations in different climates or extra strength of framing for snow loading or earthquake. Many of the code requirements that are mentioned above apply mostly to private residences or alterations to them, but they also apply to multifamily buildings, small office buildings, warehouses, etc.

The Enforcement: Generally, the local administration and enforcement of codes is by a building inspector or engineer who has the authority to approve materials and methods which may not be directly referenced in the code. Qualified people are necessary to administer a building code properly. No matter how good a code may be, it must be enforced by someone experienced, informed and objective. Most builders do not complain about the careful and competent inspector who is consistent and tough, but complain about the part-time inspector who does not understand construction and may be arbitrary and inconsistent. The competent code enforcer who knows his job knows when the letter of the code should prevail and when subjective interpretation should be made. However, the local code administrator is faced continually with the difficulties of judgment and may well argue that his job is to check compliance.

The following is a sample form for adoption of the Uniform Building Code and Uniform Building Code Standards.

SAMPLE ORDINANCE FOR ADOPTION OF THE UNIFORM BUILDING CODE AND UNIFORM BUILDING CODE STANDARDS

ORDINANCE NO. ______

An ordinance of the ______(jurisdiction)______ regulating the erection, construction, enlargement, alteration, repair, moving, removal, demolition, conversion, occupancy, equipment, use, height, area and maintenance of all buildings and/or structures in the ______(jurisdiction)______; providing for the issuance of permits and collection of fees therefor; providing penalties for the violation thereof; repealing Ordinance No. ______ of the ______(jurisdiction)______ and all other ordinances and parts of the ordinances in conflict therewith.

The ______(governing body)______ of the ______(jurisdiction)______ does ordain as follows:

Section 1. That certain documents, three (3) copies of which are on file in the office of the ______(jurisdiction's keeper of records)______ and the ______(jurisdiction)______; being marked and designated as "Uniform Building Code" (and "Uniform Building Code Appendix"), 1979 edition, and the "Uniform Building Code Standards," 1979 edition, published by the International Conference of Building Officials, be and the same is hereby adopted as the code of the ______(jurisdiction)______ for regulating the erection, construction, enlargement, alteration, repair, moving, removal, demolition, conversion, occupancy, equipment, use, height, area and maintenance of all buildings and/or structures in the ______(jurisdiction)______ providing for issuance of permits and collection of fees therefor; providing penalties for violation of such code; and each and all of the regulations, provisions, penalties, conditions and terms of such "Uniform Building Code," 1979 edition, and the "Uniform Building Code Standards," 1979 edition, published by the International Conference of Building Officials, on file in the office of the ______(jurisdiction)______ are hereby referred to, adopted and made a part hereof as if fully set out in this ordinance.

Section 2. That Ordinance No. ______ of ______(jurisdiction)______ entitled *(fill in here the complete title of the present building ordinance or ordinances in effect at the present time so that they will be repealed by definite mention)* and all other ordinances or parts of ordinances in conflict herewith are hereby repealed.

Section 3. That the ______(jurisdiction's keeper of records)______ shall certify to the adoption of this ordinance and cause the same to be published.

Section 4. That if any section, subsection, sentence, clause or phrase of this ordinance is, for any reason, held to be unconstitutional, such decision shall not affect the validity of the remaining portions of this ordinance. The ______(governing body)______ hereby declares that it would have passed this ordinance, and each section, subsection, clause or phrase thereof, irrespective of the fact that any one or more sections, subsections, sentences, clauses and phrases be declared unconstitutional.

Section 5. That this ordinance shall be and is hereby declared to be in full force and effect, from after ______(time period)______ from this date of final passage and approval.

FIGURE 1

Types of Building Codes

The homebuilding industry is enmeshed in an extraordinary network of established building codes which attempt to assure that building construction will be safe. They generally accomplish that purpose; but codes and code administration are criticized widely as being restrictive to home building progress by retarding the acceptance of new and improved uses of materials and methods, and thereby unnecessarily increasing the costs of construction. In some instances, the adoption of improved codes has stimulated better building practices. But the existing complex and chaotic building code situation is recognized as one of the problems facing the homebuilding industry today because of the use of "specification" type codes, the lack of code uniformity, the multiplicity of codes, the slow response of codes to change and inadequate performance standards.

Specification Type Code: A specification type building code establishes building construction requirements by reference to particular materials and methods. Many of these codes are out-of-date, unrevised, and frequently are based on obsolete methods.

Performance Type Code: A performance type of code does not limit the selection of methods and systems to a single type, but establishes the requirements of performance for building elements. Such a code establishes design and engineering criteria without reference to specific methods of construction. Any system performing as the code requires would be acceptable, regardless of materials and methods used.

The use of true performance codes in all of the communities of this country would be ideal but is impractical. Permitting the house and elements of the house to be built with any method as long as certain performance criteria are met is idealistically fine and proper by practicably unworkable. Local code administration would have to be in the hands of extraordinarily competent people equipped to interpret performance criteria and evaluate any proposed methods, uses or systems.

A workable solution lies somewhere between the pure performance and the specification codes. Codes may be considered performance codes if they adequately provide for the acceptance of alternant methods and systems.

This suggests that the determination of performance criteria and judgment as to whether methods and systems do perform suitably must be made by technically qualified people, not at the local level. The model code groups are better qualified to offer this type of service at this time. The model code groups, supported by building officials themselves, have performed a great service to the homebuilding industry. But model codes have not fully solved the problems of code uniformity. Only about one-fourth of the cities using model codes have adopted the model without some modification. The National Association of Home Builders points out: "The model codes are developed by qualified people and, in general, are up to date, but over 30% of the changes made 'to suit local conditions' come from local codes prepared 20 or more years ago". The modification of model codes by the local community often is influenced by self-interest groups.

Model Codes

To help fill the need for workable codes, four major organizations of industry and professional groups and several states have developed building codes which may be adopted into law for use in local communities. The codes commonly are referred to as model codes. The nationally recognized model codes and sponsoring organizations are given in table 1. These model codes have been widely accepted by local communities and now are used by more than 80% of the communities with a population over 10,000. The organizations which prepare model codes also provide for the continuous updating necessary to include recommendations based on industry research and the development of new materials and methods.

National Building Code: The first model building code was introduced in 1905 by the National Board of Fire Underwirters, now known as the American Insurance Association. The organization was concerned primarily with public protection against fire hazards, and this original code was designed to guide communities in setting up fire safety standards. With subsequent additions, however, it laid the groundwork for the development of building codes throughout the country. Now known as the National Building Code, an abbreviated edition also is available for communities needing a less extensive code. The National Building Code does not cover the subjects of plumbing and wiring.

Uniform Building Code: In 1927, the International Conference of Building Officials (initially the Pacific Coast Building Officials Conference) published its Uniform Building Code. Since that time, the code has gained wide national acceptance, particularly in the West. The International Conference of Building Officials (ICBO) also publishes the Uniform Building Code Standards, Uniform Mechanical Code, Uniform Housing Code, Uniform Code for the Abatement of Dangerous Buildings, Uniform Sign Code, Uniform Fire Code, Uniform Plumbing, and One- and Two-Family Dwelling Code.

TABLE 1 -- MODEL CONSTRUCTION CODES AND SPONSORING ORGANIZATIONS

BUILDING CODES	
Basic Building Code	Building Officials and Code Administrators International, Inc.
National Building Code	American Insurance Association
Southern Standard Building Code	Southern Building Code Congress
Uniform Building Code	International Conference of Building Officials
One- and Two-Family Dewlling Code	All of the above
ELECTRICAL CODES	
National Electrical Code	National Fire Protection Association
One- And Two-Family Electrical Code	National Fire Protection Association
HOUSING CODES	
Basic Housing--Property Maintenance Code	Building Officials and Code Administrators International, Inc.
Housing Code	American Public Health Association
Southern Standard Housing Code	Southern Building Code Congress
Uniform Housing Code	International Conference of Building Officials
PLUMBING CODES	
Basic Plumbing Code	Building Officials and Code Administrators International, Inc.
National Plumbing Code	American Society of Mechanical Engineers
Southern Standard Plumbing Code	Southern Building Code Congress
Uniform Plumbing Code	International Association of Plumbing and Mechanical Officials
MISCELLANEOUS CODES	
Basic Fire Prevention Code	Building Officials and Code Administrators International, Inc.
Fire Prevention Code	American Insurance Association
Safety Code For Mechanical Refrigeration	American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

Southern Standard Building Code: The Southern Building Code Conference drafted the Southern Standard Building Code in 1945. Now used extensively in the southern states, it was designed to meet special problems in that region. The Southern Building Code Congress (SBCC) also publishes the Southern Standard Plumbing Code, Southern Standard Gas Code, Southern Standard Mechanical Code, Southern Standard Housing Code, and the One- and Two-Family Dwelling Code.

Basic Building Code: The Building Officials and Code Administrators International, Inc. (BOCA) developed the Basic Building Code in 1950. Substantially revised, the Basic Building Code is still widely used, primarily in the East and Midwest. BOCA also publishes the Basic Fire Prevention Code, Basic Housing-property Maintenance Code, Basic Plumbing Code, Basic Mechanical Code, and the One- and Two-Family Dwelling Code.

One- And Two-Family Dwelling Code: In 1971 the four code groups adopted a consensus code titled the One- and Two-family Dwelling Code. This model code contains requirements for building, planning and construction, including specifications for heating, cooling and plumbing. The One- and Two-Family Electrical Code published by the National Fire Protection Association is also included in the One- and Two-Family Dwelling Code by reference. Publication of this single national model code constituted a significant step toward uniform minimum regulations, but it remains for the code to be recognized and adopted by state and local governments. The National Plumbing Code, The Uniform Plumbing Code, Uniform Heating and Comfort Cooling Code, and the National Electric Code also have been developed to cover the special concerns of public health and safety as affected by plumbing, heating, cooling and wiring of buildings. Many local communities also have adopted these codes, since some of the model codes do not cover these subjects.

National Plumbing Code: The National Plumbing Code has been developed as an American National Standard, ANSI A40.8-1955, with the cooperation of several engineering, trade and industry organizations. The purpose of the National Plumbing Code is to protect the public health. The code, therefore covers the proper design, installation and maintenance of plumbing systems based on principles of sanitation and safety, and not necessarily on efficiency, convenience or adequacy for good service or future expansion of system use. Standards for materials and fixtures are based largely on other industry specifications such as Commercial Standards, American Standards, and ASTM Specifications (American Society For Testing And Materials).

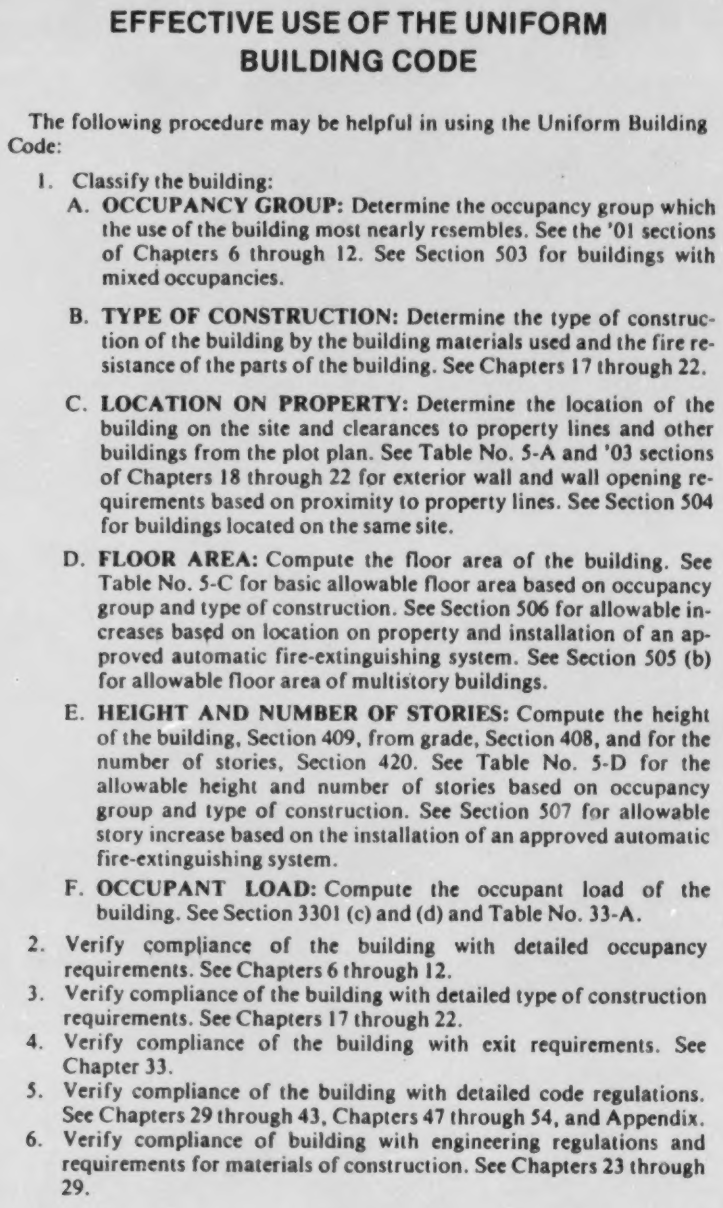
Uniform Plumbing, Uniform Heating and Comfort Cooling Codes: In 1929, the Western Plumbing Officials Association established the first Uniform Plumbing Code, and since that time has added the Uniform Heating and Comfort Cooling Code. These codes have been developed in the interest of public health and safety and cover the design, installation and maintenance of plumbing, heating and air conditioning systems. Materials and equipment standards are based largely on other industry specifications and standards. These codes have gained widespread use in the western states, as well as in other communities across the counrty.

National Electric Code: The National Electric Code was produced by the National Fire Protection Association and has been adopted as an American National Standard, ANSI C1-1971. The purpose of the National Electric Code is to assure the safeguarding of persons and of buildings and their contents from hazards arising from the use of electricity for light, heat, power and other purposes. The code contains basic minimum provisions for safety which, with proper maintenance, will result in installations free from hazard, but not necessarily efficient, convenient or adequate for good service or future expansion of electrical use. The Code makes reference to many other industry specifications such as Underwriters' Laboratories labels and requirements. It is revised periodically and is adopted by reference into many building codes.

National Fire Protection Association: The National Fire Protection Association (NFPA) was organized in 1896 to promote the science and advance the methods of fire protection. NFPA is a non-profit educational organization which publishes and distributes various publications on fire safety--including model codes, materials standards, and recommended practices. These technical materials, aimed at minimizing losses of life and property by fire, are prepared by NFPA Technical Committees and are adopted at the annual meeting of the Association. All are published in the National Fire Codes, a 10 volume compilation of NFPA's official technical material. The National Electrical Code is a part of Volume 5.

Using A Model Code

Figure 2 illustrates the effective use of the Uniform Building Code.



EFFECTIVE USE OF THE UNIFORM BUILDING CODE

The following procedure may be helpful in using the Uniform Building Code:

1. Classify the building:
   - A. **OCCUPANCY GROUP:** Determine the occupancy group which the use of the building most nearly resembles. See the '01 sections of Chapters 6 through 12. See Section 503 for buildings with mixed occupancies.
   - B. **TYPE OF CONSTRUCTION:** Determine the type of construction of the building by the building materials used and the fire resistance of the parts of the building. See Chapters 17 through 22.
   - C. **LOCATION ON PROPERTY:** Determine the location of the building on the site and clearances to property lines and other buildings from the plot plan. See Table No. 5-A and '03 sections of Chapters 18 through 22 for exterior wall and wall opening requirements based on proximity to property lines. See Section 504 for buildings located on the same site.
   - D. **FLOOR AREA:** Compute the floor area of the building. See Table No. 5-C for basic allowable floor area based on occupancy group and type of construction. See Section 506 for allowable increases based on location on property and installation of an approved automatic fire-extinguishing system. See Section 505 (b) for allowable floor area of multistory buildings.
   - E. **HEIGHT AND NUMBER OF STORIES:** Compute the height of the building, Section 409, from grade, Section 408, and for the number of stories, Section 420. See Table No. 5-D for the allowable height and number of stories based on occupancy group and type of construction. See Section 507 for allowable story increase based on the installation of an approved automatic fire-extinguishing system.
   - F. **OCCUPANT LOAD:** Compute the occupant load of the building. See Section 3301 (c) and (d) and Table No. 33-A.
2. Verify compliance of the building with detailed occupancy requirements. See Chapters 6 through 12.
3. Verify compliance of the building with detailed type of construction requirements. See Chapters 17 through 22.
4. Verify compliance of the building with exit requirements. See Chapter 33.
5. Verify compliance of the building with detailed code regulations. See Chapters 29 through 43, Chapters 47 through 54, and Appendix.
6. Verify compliance of building with engineering regulations and requirements for materials of construction. See Chapters 23 through 29.

FIGURE 2

Standards

In selecting materials or determining the suitability of materials and methods, the specifier and the builder make reference to a variety of industry standards. The preparation of standards may be the effort of a group of manufacturers, professionals or tradesmen seeking simplification and efficiency or the assurance of a minimum level of quality. Standards also may be the work of a governmental agency or other group interested in establishing minimum levels of safety and performance. Hence, standards take a variety of forms depending on source and purpose.

Some standards specify the constituents of a material, its physical properties and performance under stress and varying climatic conditions. Some may define terms, classify materials, state thicknesses, lengths and widths. Standards may spell out the methods of joining separate materials, of fabricating various parts of construction, or of assembling systems.

In general, construction standards have two basic objectives: (1) to establish levels of quality which may be recognized by the user, specifier, approver or buyer of a material, product or system; and (2) to standarize or simplify such variables as dimensions, varieties or other characteristics of specific products so as to minimize the variation in manufacture or use.

Construction standards are used by manufacturers, specifiers, consumers, communities and others. These standards may be used either separately or within collections of standards such as building codes, HUD Minimum Property Standards, and architectural specifications. These larger works have broader objectives than standards alone. Codes are concerned basically with minimum acceptable standards of public health, safety and welfare. HUD Minimum Property Standards establish minimum requirements of design and construction for the insurance of mortgage loans. Architectural specifications establish requirements of materials, equipment, finish, and workmanship as desired by an architect for a particular job.

Many industry groups provide programs of certification in which materials and products are marked or labeled to indicate that they have been produced to meet particular standards of manufacture and/or performance. Certification, when based on independent inspection and testing according to industry specifications, can provide assurance that certain standards have been met. Manufacturers, tradesmen and suppliers, working through trade associations and industry societies, provide most of the active basic preparation of materials specifications and performance criteria.

Trade Associations: A trade association is an organization of individual manufacturers or businesses engaged in the production or supply of materials and/or services of a similar nature. A basic function of a trade association is to promote the interests of its membership. Those interests generally are best served by the proper use of the groups' materials, products and services. The proper use of homebuilding materials and methods is guided largely by the development of suitable levels of quality for the manufacture, use and installation during construction. Some of the most important activities of trade associations are directed toward research into the use and improvement of materials and methods, and toward formulating specifications and performance standards. In many instances, trade associations also sponsor programs of certification in which labels, seals, or other identifiable marks are placed on materials or products manufactured to particular standards or specifications.

Specifications-Standards: Specifications are clear and accurate descriptions of technical requirements of materials, products or services. They may state requirements for quality and the use of materials and methods to produce a desired product, system, application or finish. Specifications become standards when they are adopted for use by a broad group of manufacturers, users, or specifiers.

The American Plywood Association is a good example of a trade association active in developing standards. This association is supported by a large membership of manufacturers producing softwood plywood. The production of various types and grades of plywood requires the selection and classification of wood veneers according to strength and appearance. Producing plywood from these veneers demands careful manufacturing control of such factors as moisture content and adhesive type. The completed product, properly assembled, bonded and finished, must conform to a body of material specifications, manufacturing procedures and performance testing standards. Plywood manufacturers, through their own research and combined efforts within the American Plywood Association, financially and technically support the research and development of criteria which the association formulates into industry specifications. The written specifications become the standards to which members of the association agree to produce plywood.

The standards developed by trade associations often are adopted by or used as a base from which other groups, such as the American National Standards Institute (ANSI), may develop standards. For example, industry standards may be promulgated as ANSI Standards which are often incorporated into the HUD Minimum Property Standards or building codes.

Certification: Trade associations and industry groups also may provide assurance that established standards have been met in manufacture. Certification of quality may take the form of grademarks, labels, or seals. For example, the American Plywood Association also maintains a continuing program of product testing during and after manufacture with grade markings applied directly to the plywood. The grademark is a visible statement that the specifications and standards of the American Plywood Association and appropriate Product Standard has been met.

American Society For Testing and Materials (ASTM): The American Society for Testing and Materials is an international, privately financed, non-profit, technical, scientific and educational society. The objectives of the Society are "the promotion of knowledge of the materials of engineering, and the standardization of specifications and methods of testing". Two general categories of information and publications are available from ASTM: (1) ASTM Standards which include definitions of terms, specifications and methods of test for materials and construction used throughout the industry; and (2) data dealing with research and testing of materials published in monthly and quarterly journals, and special technical publications which cover symposia and collections of data. ASTM Specifications are designated by the initials ASTM, followed by a code number and the year of last revision. For example, ASTM C55-66T is the ASTM tentative specification for "Concrete Building Brick" as last revised in 1966.

American National Standards Institute (ANSI): The American National Standards Institute is the name adopted by the United States of America Standards Institute (USASI) in October 1969. USASI was created in 1966 by the complete reorganization of the earlier standards organization, the American Standards Association (ASA). This restructuring provided for a Member Body Council, a Company Member Council and a Consumer Council.

The Member Body Council, comprised of approximately 140 national trade, professional and scientific associations, is responsible for establishing and maintaining procedures for the approval of standards as American National Standards. The Company Member Council consists of several hundred industrial firms and representatives of labor and government. The Company Member Council and the Consumer Council provide membership on the Board of Directors and work closely with the Member Body Council in recommending areas of standardization deemed essential, and in reviewing standards.

ANSI is privately financed, its financial support being derived from voluntary membership dues and from the sale of the published American National Standards. These are national standards arrived at by common consent, are available for voluntary use, and often are incorporated in regulations and codes. The ANSI does not formulate standards itself, but rather acts as the national coordinating institute for voluntary standardization and promotes knowledge and voluntary use of standards.

An American National Standard is designated by code number and date of last revision. For example, ANSI A12.1-1967 covers "Safety Requirements for Floor and Wall Openings, Railings and Toe Boards", which was originally adopted by ASA in 1932, later revised in 1967, and became an American National Standard upon adoption in 1979.

Underwriters' Laboratories, Inc. (UL): Underwriters' Laboratories, Inc. is chartered as a nonprofit organization to establish, maintain and operate laboratories for the examination and testing of devices, systems and materials. The main objectives of UL are: (1) "to determine the relation of various materials, devices, constructions, and methods to life, fire, and casualty hazards"; (2) "to ascertain, define and publish Standards, Classifications, and Specifications for materials, devices, construction, and methods affecting such hazards"; and (3) to provide "other information tending to reduce and prevent loss of life and property from fire, crime, and casualty".

UL also contracts with manufacturers and other parties "for the examination, classifcation, testing, and inspection of buildings, materials, devices, and methods with reference to life, fire, and casualty hazards". Findings are circulated by various publications to insurance organizations, other interested parties and to the public. The UL also contracts to provide product certification by attaching certificates or labels to examined, tested or inspected materials, devices, and products.

The Underwriters' Laboratories, Inc. originally was formed in 1894 and was subsidized by the stock insurance companies. Before the turn of the century, as new electrical device and products came rapidly into the market, it became necessary to test and inspect them to insure public safety. The National Board of Fire Underwriters (now the American Insurance Association) organized and sponsored Underwriters' Laboratories, Inc. to meet this demand. UL became self-supporting in about 1916.

To sustain the testing program, UL contracts with the product submittor for testing, report and listing of devices, systems or materials on a time and material basis. The cost of the inspection service is provided for either by an annual fee or by service charges for labels, depending on the type of service. Materials and products carrying UL labels and certificates must meet published standards of performance and manufacture and are subjected to UL inspection during manufacture.

Although primarily interested in public safety, UL's policy is to list and label only products which perform their intended function. If a product does not perform with reasonable efficiency, even though it may be perfectly safe, it does not quality for the UL label.

Underwriters' Laboratories, Inc. Standards are designated by the initials UL, followed by a code number. No date of last revision is indicated by the number. For example, UL55B covers "Class 'C' Asphalt Organic-Felt Sheet Roofing and Shingles" and was last revised in 1962.

IMPEDIMENTS TO SOLAR SYSTEMS

Solar System Hazards

The principal hazards to health and safety from solar energy systems are derived from the risk of leakage, fire, or explosion (due to damage from high temperatures, pressures, corrosion, other component failure, or impact) and the risk of human contact with hot surfaces or broken glazing. There is also some risk of contamination of drinking water with toxic coolants if plumbing is not properly done. And there are potential structural problems from high winds or snow loads if collectors are not strong enough.

Impediments Imposed By Codes

Building codes, specifically applicable to hot water and space heating, air conditioning, and electrical equipment, seldom contain provisions covering onsite solar systems. Under the major model codes a "heating appliance" is presently defined as a device that generates heat from solid, liquid, or gaseous fuels, or with electricity. Solar sources are not mentioned, nor are they included in the definitions of ventilating or cooling appliances.

For most kinds of construction materials and equipment, nationally recognized standards, test methods, and testing agencies are specified in the codes. Two examples are the Underwriters Laboratories, Inc., for electrical equipment, and the American Gas Association, for gas equipment. For solar energy systems, such nationally recognized standards, test methods, and listing agencies do not exist.

A difficulty encountered with any new technology, and particularly one involving as many small and inexperienced manufacturers as in the current solar energy industry, is that it is necessary that standard testing procedures be developed rapidly, and in step with the development of each type of technology It is also necessary, however, that these standards be reviewed constantly so that new and different design approaches are not inadvertently ruled unacceptable.

Under the model codes, heating, ventilating, and cooling appliances must be approved by building officials or carry the label of an approved testing agency or laboratory. There is no agency to certify compliance and attach labels to solar equipment, nor is there a nationally recognized set of standards on which to base compliance.

Solar heating systems are therefore at a potential disadvantage as compared to conventional systems, which can be approved for installation with a simple showing of a label.

While the lack of standards may be the most important building-code problem for solar systems, there are other possible impediments. Limitations on the overhang of roofs and awnings, for example, may thwart some passive solar designs.

Unrealistically high demands on solar heating systems for buildings may result from high minimum temperature requirements (72°F under the ICBO code's standards) and from large minimum ventilation and light requirements for windows in the model codes.

Limitations on residential building heights that may preclude roof collectors, chimney and plumbing clearances, application of new standards to old buildings in retrofit stiuations, roof slope requirements, and implied prohibitions against using solar collectors as integral parts of a structure's roof or walls.

Standards for prefabricated assemblies may result in costly tests to demonstrate weather resistance.

Impediments Imposed by Building Officials

A structural component that is unique to solar systems is the collector. Solar collectors are not dealt with by present building codes. Once heat is collected or electricity is generated, it is transported away, stored, and utilized by means that have been long used in conventional energy systems. Pipes, ducts, valves, storage tanks, controls, wiring, storage batteries, etc., are already provided for, even though their use may be novels.

Alternative materials, equipment, or methods must be shown, to the building officials' satisfaction, to be at least the equivalent of that prescribed in the codes in strength, fire resistance, durability, quality, effectiveness, and safety. Demonstrating that these six criteria have been met may be difficult. Building officials may require testing, at the applicants' expense, by approved testing officials (chosen by the building officials) using approved test methods (chosen by the building officials unless methods are specifically provided for in the code).

The effect of the administrative provisions is to give building officials discretion that may result in market fragmentation, delay, additional expense, and uncertainty in the processing of permit applications.

Overcoming The Impediments

Revisions To Codes: The ideal solution to potential building code problems would be nationally recognized standards and testing procedures for the various kinds of solar energy systems, and nationally recognized accrediation agencies to certify compliance with these standards and to grant listings. These standards for materials, equipment, and installation would be adopted by reference in all local and state building codes, and listing would be accepted as sufficient proof of code approval if the equipment were installed in compliance with the conditions given in the listing. Equipment standards must include both performance standards and test methods for collectors, storage, and whole systems.

Government Action: A federal solar building code or federally mandated standards would probably be constitutional, but unnecessary. Federal assistance in coordinating and certifying state solar building code programs would be beneficial, however. A variety of state approaches should be acceptable so long as the variations in code requirements are based on state and local conditions and do not unreasonably burden interstate commerce in solar equipment.

States could write statewide mandatory codes that would revise building codes to remove the problem provisions or exempt solar systems from application of particular provisions so long as the requirements of safety, health, and structural strength are met. States will of course want to test for matters bearing on these requirements. If the standards and test methods are reasonably consistent, predictable, and not unreasonably costly, the federal government should permit the states to require them.

An alternative would be federal legislation requiring states to set their own standards and revise their building codes by a specified date, or have federally determined standards and codes set for them. This could be a fast solution, but may result in enough local variation in solar energy systems to prove a burden on interstate commerce.

Or the federal government may want to support an effort to revise the model codes to remove impediments to the effective use of solar energy. This could be done by the major model code groups. Federal legislation could make such a program mandatory nationwide, or could make adoption by the states voluntary, but with incentives to make state adoption likely. The great advantage of the first option is that it would quickly result in nearly uniform nationwide standards. The federal enactment of even a national solar building code, although unprecedented, would certainly be sustained by the courts as within the broad powers of Congress to regulate commerce. Opposition to such precedent-setting legislation might be overwhelming.

Certification: There might be private, state, or federal certification of solar equipment. In this country, certification has traditionally been a private-sector function of test labs such as Underwriters' Laboratories. State certification for ratings based on thermal performance of collectors is being done in Florida, California, and other states. Early experience with federal certification of systems for the HUD demonstration program proved unsatisfactory because of lengthy delays, however, and that experience may lead to opposition to any federal certification program. Self-certification by manufacturers, provided there is some mechanism for assuring that it is done honestly, should be adequate for removing the code burden, provided the state will accept that as equivalent to code approval.

Building Officials: Impediments due to testing and approval procedures and other various requirements have not been reported as a practical problem for solar equipment users so far. It is possible that building officials will continue to look upon solar systems in a friendly way, and never apply the codes to them in the manner that the codes call for. It seems more likely that as solar systems gain popularity there will be some labor unions and manufacturers of particular types of systems who would benefit if current codes are enforced, and who would thus lobby for their strict application. If opposing forces organize before building codes are modified to accommodate solar equipment, it may be much more difficult to change the codes.

As an interim measure, State certification can provide local building officials with guidelines until a national testing and certification program can be put in place. Some states may wish to go beyond furnishing guidelines, and can write laws that require local building officials to approve solar equipment that meets State standards and is certified by State agencies.

SOLAR ENERGY BUILDING CODES AND STANDARDS

Model Document For Code Officials

During June 1980, a model document for code officials on solar heating and cooling of buildings was issued. Entitled Recommended Requirements to Code Officials for Solar Heating, Cooling and Hot Water Systems, the document represents recommended requirements sponsored by the Council fo American Building Officials (CABO) under the auspices of the American National

Standards Institute (ANSI). CABO is a cooperative effort of the three model code organizations (Building Officials and Code Administrators International, International Conference of Building Officials, and Southern Building Code Congress International) to achieve uniformity in regulations, interpretation and product approval, and to represent building officials at the national level. The recommended requirements were developed using ANSI approved CABO consensus procedures, thereby assuring technically competent committees with balanced representation. It is a product of unprecedented joint effort by representatives of industry, labor, consumers, home builders, code officials, governors, mayors, county executives and city managers. It should be a useful reference source for local officials seeking to amend local building codes to accomodate solar energy systems.

The purpose of the recommended requirements is to provide for reasonable protection of the public health and safety, while at the same time encouraging consumers, builders, designers, manufacturers, installers and others to utilize solar energy technologies while permitting experimentation and innovation.

These recommended requirements include provisions for electrical, building, mechanical and plumbing installations for active and passive solar energy systems used for space or process heating and cooling, and domestic water heating. Durability, life expectancy and related requirements of these systems are not addressed. Although installations may comply with these recommended requirements, there is no representation that the solar system will be efficient or cost effective.

These recommended requirements are not intended to be complete in themselves. In order to encourage uniform and consistent application, they provide:

1. References to relevant existing code provisions, and
2. New provisions to be considered for incorporation into existing codes.

These recommended requirements are multi-purpose in nature and will be of interest to all segments of the building community:

1. The code enforcement official will use them as a reliable reference guide for reviewing and approving solar energy installations.

2. The design professional, builder, manufacturer, supplier, and installer will have a means for determining the parameters under which components and systems will be judged.

3. The standard and code writing organization will have a means for identifying problems, setting priorities, and updating documents to provide for solar energy sytems.

4. The consumer, environmental organization, and consumer protection agency will use them to foster better public understanding of the ways in which public health and safety can be protected when utilizing solar energy systems.

Solar Energy Code For Plumbing

A Uniform Solar Energy Code developed by the International Association of Plumbing and Mechanical Officials (IAPMO) was adopted at the forty-ninth annual conference during September, 1978. The code provides for ordinance adoption, a schedule of permit fees, and provisions that apply to the erection, installation, alteration, addition, repair, relocation, replacement, maintenance or use of any solar system as minimum requirements and standards for the protection of the public health, safety, and welfare. Provisions of the code are limited to those areas applicable to installation and maintenance of plumbing systems based on principles of sanitation and safety.

Code Manual For Passive Solar Design

A reference manual for single family residential construction was issued in 1979 under the auspices of the Southern Solar Energy Center, one of four regional centers established by the Department of Energy to help industry commercialize economically viable solar applications. One of the Center's most important missions is to work with the building community to promote energy efficient/solar building construction, and to remove barriers to solar use. This referance manual represents an effort to give builders within the region a practical tool to clarify the impact of building and energy codes on passive residential designs.

Building codes and their enforcement have a profound, and for the most part, beneficial effect on the quality and safety of homes. However, certain code regulations may unintentionally conflict with passive designs, which were not envisioned when the laws were created. As passive solar use gains wider acceptance, these conflicts will become more evident. The reference manual identifies problems, thereby warning designers and builders of potential conflicts, while helping code officials and legislative groups to understand and give consideration to special passive solar designs. The information contained within the guide is to be updated periodically to keep builders informed of the latest changes in regulations and codes.

The workbook is divided into three parts. Part I contains general information on types of passive solar techniques and a method for estimating passive solar performance. Part II contains descriptions of the important codes and standards that are later referenced in Part III of the workbook. Each of the code descriptions lists the items in the code which could have a potential impact on a passive solar design and concludes with an overall analysis of the effect the code has on the use of such techniques. Part III contains summaries of state and local codes and code agencies. Included is a synopsis of statements made by the building official about the use of passive solar in his jurisdiction and descriptions of any related programs (such as those of utility companies). The last entry gives, briefly, the stated requirements to file for a building permit.

Performance Criteria for Commercial Building Solar Energy Systems

Interim Performance Criteria For Solar Heating And Cooling Systems In Commercial Buildings, a document prepared by the National Bureau of Standards, was issued during November, 1976. Intended primarily for use in the solar demonstration program, the performance criteria, however, were prepared such that evolution into definitive performance criteria useful in the development of provisions for model and local building codes as well as Federal specifications would be possible.

Objectives: The interim criteria have the following objectives:

1. To provide designers, manufacturers and evaluators with the technical performance criteria that will be used for the commerical solar heating and cooling demonstration program.

2. To establish technical performance levels that will be used for the evaluation and procurement of systems, subsystems and components for the commercial solar heating and cooling demonstration program.

3. To provide a basis for the development of more definitive performance criteria at a later date.

Scope: The interim performance criteria given for hardware related items including space heating systems, hot water systems, space cooling systems, or combinations thereof, and their various subsystems, components, and materials are intended to:

1. Establish minimum levels for health and safety that are consistent with those presently established for conventional systems used in commercial applications.

2. Ensure that the proposed heating, cooling, and hot water systems, or combinations thereof, are capable of providing levels of performance consistent with those provided by conventional systems used in commercial applications.

3. Verify that proposed systems, subsystems, and components are capable of providing their design performance levels.

4. Ascertain that the systems, subsystems, and components are durable, relaible, readily maintainable and generally constructed in accordance with good engineering practice.

The interim performance criteria are intended to be flexible in order to allow freedom of design and encourage innovation in keeping with the intent of Public Law 93-409, The Solar Heating and Cooling Demonstration Act of 1974.

Standard For Energy Conservation In New Building Design

ASHRAE Standard 90-75, issued by The American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., is the first national technical standard aimed specifically at reducing energy consumption in buildings. It prescribes performance levels for individual building components, but has provisions for evaluation of alternate designs. As such, it provides the technical basis for subsequent legal models.

Standard Method For Measuring Solar-Optical Properties Of Materials

ASHRAE Standard 74-73 was issued as a standard method of measuring and reporting the Solar-Optical properties of materials. The standard includes consideration of the direction and nature of the direct, diffuse, and reflected radiant energy incident on the sample of material; limits the wavelength range to 0.3 to 3.0 micorns, with a spectral distribution equivalent to the solar spectrum at a specified air mass; and specifies equipment and procedures for determining the transmitting, reflecting, and absorbing characteristics of the sample as measured. This standard provides the technical basis for considerations in both passive designs and other solar collecting devices and systems.

Standard Methods of Testing To Determine The Thermal Performance of Solar Collectors

ASHRAE Standard 93-77, (ANSI B198.1-1977), was issued in 1977 as a test procedure whereby solar energy collectors can be tested both indoors and outdoors, rated in accordance with their thermal performance, and provide means for determining the time constant and the variation of collector efficiency with changes in the angle of indidence between the sun's direct rays and the normal to the collector aperture. Provisions for testing both concentrating and flat-plate collectors in which a fluid enters the collector through a single inlet and leaves the collector through a single outlet are included. The heat transfer fluid may be either a liquid or a gas, but not a mixutre of the two phases. This standard is not applicable to those collectors in which the thermal storage unit is an integral part of the collector to such an extent that the collection process and the storage process cannot be separated for the purpose of making measurements of these two processes (i.e., passive units would normally not be covered).

Standard Methods of Testing Thermal Storage Devices Based On Thermal Performance

ASHRAE Standard 94-77 (ANSI B199.1-1977) was issued in 1977 as a complementing test method to ASHRAE Standard 93-77, the purpose being to provide a standard procedure for determing the thermal performance of thermal energy storage devices used in heating, air conditioning, and service hot water. This standard applies to sensible heat and latent heat-type thermal energy storage devices in which a transfer fluid enters the device through a single inlet and leaves the device through a single outlet. The standard is not applicable to those configurations in which there is simultaneous flow into the storage device through more than one inlet and/or simultaneous flow out of the storage device through more than one outlet. The transfer fluid can be either a gas or a liquid or a mixture of the two. The standard does not include factors relating to cost, life, relaibility, or the consideration of requirements for interfacing with specific heating and cooling systems.

Certification And Accreditation

As of mid-1979, the matter of who will run a program to test, rate, and certify solar equipment and systems and who will accredit laboratories capable of doing the tests was still an open question. A number of organizations, however, were addressing the issue:

ARI Foundation: Working through the National Bureau of Standards, the ARI Foundation, Inc. (ARIF), a subsidiary of the Air-Conditioning and Refrigeration Institute, developed criteria for evaluating testing laboratories and identified those laboratories deemed qualified to test collectors according to ASHRAE Standard 93-97. ARIF also came up with a blueprint for a certification program and has since launched such an undertaking open to manufacturers.

Solar Energy Research and Education Foundation: Through a contract with the Department of Energy, the Solar Energy ReSearch and Education Foundation (SEREF), a sister organization of the Solar Energy Industries Association, has been developing a solar collector rating, certification, and labeling program which is designed to be combined with a laboratory accreditation program.

Moreover, both Florida and California have their own programs functioning and the National Bureau of Standards is assisting the Department of Energy and HUD in applying for a National Voluntary Laboratory Accreditation Program for solar collectors. This latter program is viewed as a possible permanent mechanism for accrediting laboratories that test solar equipment.

HUD MINIMUM PROPERTY STANDARDS

The National Housing Act, enacted by Congress in 1934 and amended from time to time, created the Federal Housing Administration (FHA) to stimulate home construction by insuring mortgage loans. The functions of this agency were transferred by Congress in 1965 to the newly created Department of Housing and Urban Development (HUD) and FHA became part of this larger cabinet-level department. The overall purpose of HUD is to assist in the sound development of the nation's communities and metropolitan areas. Encouragement of housing production through mortgage insurance and various subsidies has been one of HUD's chief objectives. Improvement in housing quality and in land planning standards has been another HUD objective mandated by Congress.

Not all housing programs authorized by Congress involve mortgage insurance. Prior to 1973, FHA-insured private housing had to conform to the FHA Minimum Property Standards, while subsidized public housing was regulated by a different set of standards. With the adoption in that year of the HUD Minimum Property Standards (MPS), uniform standards became applicable to all HUD housing programs. The MPS are intended to provide a sound technical basis for the planning and design of housing under the numerous programs of HUD. The standards describe those characteristics in a property which will provide present and continuing utility, durability, desirability, economy of maintenance, and a safe and healthful environment.

Environmental quality is considered throughout the MPS. As a general policy, development of all properties must be consistent with the national program for conservation of energy and other natural resources. Care must be exercised to avoid air, water, land and noise pollution and other hazards to the environment.

The Standards

Mandatory: The Minimum Property Standards consist of three volumes of mandatory standards--

1. MPS for One- and Two-Family Dwellings, HUD 4900.1;
2. MPS for Multifamily Housing, HUD 4910.1;
3. MPS for Care-Type Housing, HUD 4920.1.

Variations and exceptions for seasonal homes intended for other than year-round occupancy are listed in HUD 4900.1.

Advisory: A fourth volume, the MPS Manual of Acceptable Practices, HUD 4930.1, contains advisory and illustrative material for the three volumes of mandatory standards. Where no specific level of performance is stated in the standards, the Manual of Acceptable Practices may be used to determine acceptance or equivalence. This manual is not an additional standard, but is intended to provide information and data representing good current practice in residential design and construction technology.

Local Codes And Regulations

Standards As Codes: The Minimum Property Standards are not intended to serve as a building code. Such codes are primarily concerned with factors of health and safety and not the many other aspects of design and use which are included in the MPS as essential for continued acceptance by the occupants. Where the local code, regulation or requirement permits lower standards than MPS requirements, the MPS requirements apply for FHA-insured loan qualification. In the event the local code, regulation or requirement precludes compliance with MPS, the property may be ineligible unless the intent set forth in the MPS is fully attained by the alternate means proposed.

Compliance With Codes: The minimum standards shall not be construed as relieving the builder of his responsibility for compliance with local ordinances, codes and regulations including established requirements of a health authority having jurisdiction. HUD does not assume responsibility for enforcing or determining compliance with local codes and regulations or make interpretations regarding their application in any specific instance.

Intermediate Property Standards For Solar Systems

The matter of sufficient supplies of energy for the United States is one of our greatest concerns. The diminishing supply of conventional energy resources has made the development of new energy resources imperative. In response to these problems, HUD initiated its first Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems, HUD 4930.2, in 1977. As new technology is developed this standard will be updated and improved to include the most recent reliable information available.

The Intermediate Minimum Property Standards for Solar Heating and Domestic Hot Water Systems were prepared as a supplement to the mandatory Minimum Property Standards and deal only with the aspects of planning and design that are different from conventional housing by reason of the solar systems under consideration. In general, the solar supplement document chapters and divisions are organized to parallel the chapters and divisions contained in the Minimum Property Standards.

Application: The solar components must provide for the collection of solar energy, conversion of the solar energy to thermal energy, and distribution, storage and control of the thermal energy so obtained. Insofar as applicable, these standards apply to active and passive solar energy systems that utilize building elements, mechanical subsystems, or combinations thereof.

Variations To Standards: The solar supplement standards are intended to encourage the use of new or innovative designs, technologies, methods or materials in solar applications. These features include designs, methods of construction, systems, subsystems, components, materials and processes which do not comply with the MPS and the solar supplement, and whose acceptance cannot be determined by other provisions of the standards. Alternatives, nonconvnetional or innovative designs, methods, and materials shall demonstrate, however, equivalent quality to the standards in operating effectiveness, structural soundness, durability, economy of maintenance or operation, and usability. Provisions for variations to standards are provided in the document.

WARRANTIES

Sales contracts for such things as mechanical devices, electrical appliances, and automobiles usually include statements known as warranties or guarantees. These statements are promises made by the seller or manufacturer assuring the purchaser of satisfaction in the use of the merchandise. A warranty, as the word is used here, is some undertaking of the seller with respect to the goods he sells. The seller may never use the word "warranty", but nevertheless find himself answerable in damages to the buyer for a breach of warranty. But this has not always been the law. The courts, in the early hisotry of the law of sales, rigidly applied the maxim caveat emptor -- let the buyer beware. The duty, therefore, was imposed on the buyer to examine the article he was buying and act on him own judgement and at his own risk. The emphasis today is placed on the maxim caveat venditor -- let the seller beware. This does not mean that the seller is liable merely because the buyer is disappointed with his bargain. It does mean the seller is liable for his express warranties and the warranties implied by law. It is well to keep in mind, however, that a warranty is part of the contract. It now remains to discuss:

1. The express warranty;
2. The implied warranty of quality;
3. Exclusion of Warranties;
4. Product liability;
5. The Warranty Act;
6. Warranties and Solar Energy Systems.

The Express Warranty

Affirmation Or Promise: An express warranty need not be in any special form nor is it necessary to use the word "warranty" or any word of similar import. Any affirmation of fact or any promise by the seller relating to the goods is an express warranty if the natural tendency of such affirmation or promise is to induce the buyer to purchase the goods. Statements, however, which are the opinion or the belief only of the seller, commonly referred to as "sales talk" or "puffing", are permissible in the law of sales. The legal distinction between sales talk and a warranty is often said to be the distinction between a statement of opinion and a statement of fact. It is to be realized, however, that any false statement in regard to the basis of value, such as the book value of the goods or the past income of the property, may amount to a false representation. The distinction between a statement of opinion and a statement of fact and those statements which, amounting to false representations with intent to defraud, give rise to a remedy in tort for fraud and deceit.

Statements of opinion include words of commendation or praise, such as "valuable" or "the best product on the market", which are in their nature dependent on individual opinion, but statements of fact generally include words that are capable of proof or disproof, such as "this dress is 100% wool".

It should be pointed out that if the actual information of the buyer is by him known to be equal or superior to that of the seller, reliance on the statement of the seller is not justified. The factual situations of the particular case are decisive as to whether or not the seller has made an express warranty because, in the final analysis, it is the natural consequence of what the seller says and the reliance thereon of the buyer that are important in determining whether or not the seller has made an express warranty.

Sale By Sample, Model, Or Description: Section 2-313 of the Warranty Act provides that an express warranty may be created in a sale by sample, model or description. A sale by sample is created when the seller actually draws a sample from the bulk of the goods. A sale by model is created when the seller offers a model for inspection when the goods are not readily available. The whole of the goods, however, must conform to the sample or model. A sale by description may be made by patent name, trade name, blueprints, or the like. The mere exhibition of a sample or model or the use of trade names does not of itself create a warranty. Any of these factors, however, will create an express warranty if made a part of the basis of the bargin. If the warranty is made after the sale--as where the buyer is taking delivery--the warranty need not be supported by consideration since it is a modification. Irrespective of the time when the warranty is made, it is always a question of fact whether the language, samples, or models are to be regarded as a warranty, it may be that recovery will be allowed on an implied warranty.

The Implied Warranty Of Quality

There are two implied warranties of quality, the warranties of merchantability and fitness for a particular purpose. These warranties, however, are not necessarily the only implied warranties. Other implied warranties may arise from a course of dealing or usage of trade.

Warranty Of Merchantability: Section 2-314 of the Warranty Act, which is restricted to merchants, defines the term "merchantability" in detail. The term, broadly stated, means that the goods are of fair average quality or that they will pass in the trade without objection. The Code expressly provides that the merchant-seller impliedly warrants that the goods are fit for the ordinary purpose for which they are used. This provision differs from the "fitness for particular purpose" warranty. For example, shoes are generally used for the purpose of walking upon ordinary ground. A seller, however, may or may not know that a particular pair was selected to be used for climbing mountains. The seller also warrants that the goods are adequately contained, packaged, and labeled if the nature of the goods and of the transaction require a certain type of container, package, or label and that the goods conform to the representations made on the label or container. As for the requirement that the container be adequate, suppose Brown purchases fruit juice contained in a glass bottle, and, upon drinking the juice, is injured because of chipped glass. He could recover for breach of warranty of merchantability even though the fruit juice itself is wholesome. It is expressly provided that the serving of food or drink to be consumed on premises or elsewhere is a sale. The warranty of merchantability, therefore, includes the serving of food or drink. It is generally held, however, that such things as an occasional clam shell in clam chowder are not foreign to the product and are to be expected.

Warranty Of Fitness For A Particular Purpose: This warranty--commonly referred to as a warranty of suitability--is a warranty that the goods will prove fit for the purpose for which they are purchased. This warranty will be implied whether the seller is or is not a merchant if the buyer:

1. Expressly or impliedly makes known to the seller the particular purpose for which the goods are wanted, and

2. Relies upon the skill and judgment of the seller in the selection of the goods.

Both of these requirements are essential. The first element may be satisfied where the seller is apprised of the purpose of the buyer from the very nature of the transaction. The seller obviously knows that a fur coat is bought to be worn as a garment. The buyer, however, must make a particular purpose known to the seller if a special or unusual purpose is intended. A buyer who wants to purchase a pair of shoes for the particular purpose of climbing mountains, therefore, must make that purpose known to the seller.

The sale of goods today is accomplished to a great extent by the use of trade names. Designation of an article by its trade name, however, is only one of the facts to be considered. The implied warranty of fitness applies, therefore, where the seller recommends an article having a trade name as being suitable for the particular purpose stated by the buyer. But it must appear that the buyer did not order the article by its trade name. The buyer who insists on a particular brand or trade name would not be relying on the skill and judgment of the seller. The buyer would be relying on the reputation of the branded article rather than upon the judgment of the seller. The test, whether the goods are purchased by trade names or otherwise, is whether or not the necessary facts are proved by showing knowledge of the seller of the particular purpose of the buyer and the required reliance by the buyer on the superior skill and judgment of the seller.

Exclusion Of Warranties

The parties may desire some particular kind of warranty or they may desire to eliminate the warranties provided for by the Code (the FTC promulgation of the Warranty Act). This they may generally do. But it should be pointed out that if the parties desire any particular warranty or desire to exclude warranties, language should be used which clearly expresses their intention.

Express Warranty: An express warranty may be excluded, and an express warranty and a disclaimer will be constructed as consistent with each other wherever reasonable. An agreement containing an express warranty and a clause disclaiming the express warranty, however, contains inconsistent clauses. Suppose the subject matter of the sales contract is "Grandmother's Brand Pork and Beans", and the contract includes a clause which disclaims "all express warranties". This language contains an express warranty that the goods will conform to the description and a clause disclaiming the express warranty. The seller should not be able to perform by delivering another brand of pork and beans. A decision must be made, therefore, as to which clause will predominate. Section 2-316 settles the inconsistency by providing that the warranty language will prevail over the disclaimer when the two cannot be reconciled. The purpose of this provision is to protect the buyer from unexpected language of disclaimer. The seller who wishes to disclaim an express warranty, therefore, should use language of disclaimer so specific that the buyer is apprised that he is assuming the risk that the goods may not conform to the description, sample, or model.

In explaining an exclusion or modification of an express warranty, it seems necessary to recall that the parol-evidence rule (i.e. the parol-evidence rule provides that when written contracts are made between parties, the only terms that will be enforced are the terms included in the written agreement) provides that the terms of a written agreement may not be contradicted by evidence of a prior or contemporaneous oral agreement. Section 2-202, however, provides that the written agreement may be supplemented or explained by a course of dealing or usage of trade or by evidence of additional consistent terms unless the court finds that the writing was intended by both parties as a complete statement of all the terms. A disclaimer, therefore, would not be effective against oral express warranties unless it contained a clause stating that the contract contained all the terms agreed upon. This is sometimes referred to as an entirety clause, which may not be contradicted by evidence of a prior or contemporaneous oral agreement.

Implied Warranties Of Quality: A disclaimer of the implied warranty of merchantability and fitness is expressly provided for by section 2-316. The disclaimer of warranty of merchantability may be made either orally or in writing, but in either case, the language must mention merchantability; if in writing, it must be conspicuous. A written disclaimer with regard to the warranty of fitness is required, irrespective of whether or not the other terms of the contract are in writing. It is expressly provided that "to exclude or modify any implied warranty of fitness, the exclusion must be by a writing and conspicuous". Three exceptions to the above rule may be summarized:

1. No implied warranty with regard to defects arises when the buyer has examined the goods, or the sample, or the model as fully as he desired or has refused to examine the goods. It is not sufficient, however, that the goods are merely available for inspection. There must also be a demand by the seller that the buyer examine the goods fully.

2. An implied warranty can be excluded or modified by a course of dealing or course of performance or usage of trade.

3. General terms, such as "as is", "with all faults", and the like, may be used to exclude implied warranties if such expressions in common understanding call the attention of the buyer to the exclusion of warranties and make it plain that there is no implied warranty.

Product Liability

Marketing of mass-produced goods today commonly involves a succession of sales. Goods are transferred from manufacturers or producers to wholesalers or distributors, then on to retailers, and finally to consumers. The manufacturer and the consumer seldom contract with each other. Moreover, the goods are often complex, or have strange chemical components, and the user cannot be expected to test them personally, but must trust the suppliers.

At common law, all warranty liability was dependent upon a contract between the parties. Only the buyer could sue and could proceed only against the immediate seller, not against the intermediate sellers or distant manufacturer. The buyer and seller were parties to the same contract; they were said to be in privity of contract. Courts denied injured parties the right to sue anyone with whom they were not in privity of contract. The FTC Code broadens the common-law rule so that all injured persons who are in the buyer's family or household, including guests, may sue. Moreover, courts in most states have abandoned the requirement of privity of contract and permit the injured, even a non-user, to sue retailers, intermediate sellers, and manufacturers.

Today, a manufacturer or producer who makes inaccurate or misleading factual statements in advertising or labels is liable for resulting injuries to consumers. If the goods are defective or dangerous the maker is similarly liable for resulting harm. In either case, not only the manufacturer or producer, but also intermediate sellers and the immediate supplier may be liable. This responsibility or product liability may be based on warranty, fraud, negligence or, increasingly, on a theory of strict tort liability.

A manufacturer is expected to make a product safe for the purpose for which it is intended. This requires care in design and fabrication, including inspection and testing not only of its own product, but also of ingredients and components made by others. A warning notice of dangers in use of the product often is required, as, for example, on packages of cigarettes. On the other hand, there is no liability if the product is used for a purpose for which it was not intended (using gasoline to clean clothes) or which could not reasonably be foreseen. Likewise, liability may be barred if the product had been altered by the user (lengthening a ladder by nailing extensions to its legs) or if the injured person is personally found guilty of improper conduct which causes the accident (driving on a defective tire after discovering the defect, or failing to service or maintain an engine).

The Warranty Act

A reading of the historical background of the Warranty Act reveals that a consumer product would break down frequently or not work properly from the beginning, and the consumer would then learn for the first time that the product was not covered by the warranty. This situation prompted Congress in 1975 to enact the Magnuson-Moss Warranty -- Federal Trade Commission Improvement Act, commonly referred to as the Warranty Act. The rules of law contained in the discussion that follows are taken from the Warranty Act coupled with the rules and regulations promulgated by the Federal Trade Commission (FTC) pursuant to authority given the FTC by Congress. These rules and regulations pertain to consumer products costing $15 or more and apply only to written warranties.

Definitions: An understanding of the following words and terms used in the Warranty Act and the rules and regulations promulgated by the Commission may be helpful before a study of the principles of law and rules regulating warranties is undertaken.

Consumer Product: Any tangible personal property distributed in commerce and normally used for personal, family, or household purposes. This definition includes any such property intended to be attached to or installed in any real property without regard to whether it is so attached or installed.

Consumer: The word "consumer" means (1) a buyer of any consumer product, (2) any person to whom such product is transferred during the duration of a written or an implied warranty applicable to the produce, and (3) any person who is entitled by the terms of such warranty, or under applicable state law, to enforce against the warrantor the obligations of the warranty. This definition includes not only a warranty and warrantor but also a service contract and a service contractor. It expressly excludes consumer products purchased for the purpose of resale.

Seller: The word "seller" means any person who sells or offers for sale for purposes other than resale of any consumer product.

Service Contract: A contract in writing to perform, over a fixed period of time or for a specified duration, services relating to the maintenance and repair of a consumer product.

Supplier: The word "supplier" means any person engaged in the business of making a consumer product directly or indirectly available to consumers.

Warrantor: The word "warrantor", as defined by the Warranty Act, means any supplier or other person who offers to give a warranty or who may be obligated under an implied warranty.

Disclosure: The Warranty Act furnished the guidelines, and the FTC has promulgated the rules for disclosure of written warranties. The pertinent provisions of these rules, which must be clearly and conspicuously disclosed in a single document in simple and clearly understood language, may be summarized as follows:

1. The identity of the person or persons to whom the warranty is extended, and whether the enforceability of the warranty is limited to the original consumer-purchaser or is otherwise limited as to other persons.

2. A description of the products, parts, or characteristics covered by or excluded from the warranty.

3. A statement of what the warrantor will do in the event of a defect, malfunction, or failure to perform in accordance with the written warranty.

4. The terms when the warranty commences and the duration of the warranty.

5. A step-by-step explanation of the procedure which the consumer should follow to obtain performance of the warranty obligation.

6. Information concerning the availability of any informal dispute settlement mechanism.

7. Any limitation on the duration of implied warranties accompanied by a statement that the law of the particular state may not allow limitations on the duration of implied warranties.

8. Any exclusions of or limitations on relief, such as incidental or consequential damages accompanied by a statement that the law of the particular state may not allow limitations on the duration of implied warranties.

9. A statement in the following language: This warranty gives you specific relief and you may also have other rights which vary from state to state.

Pre-Sale Disclosure: The FTC, in addition to disclosure at the time of the sale has promulgated the rules of the written warranty to the consumer prior to the sale.

1. Duties of the Warrantor: The warrantor is required to provide the sellers with warranty materials by either (a) providing a copy of the written warranty with every warranted consumer product or (b) providing a label or other attachment to the product which contains the full text of the written warranty.

2. Duties of the Seller: The seller of a consumer product with a written warranty is required to make available to the view of a prospective buyer the text of the written warranty. The seller, however, is given a choice of either of two methods of making the warranty available. The first method requires the seller to clearly and conspicuously display the warranty in close conjunction with each product. The second method requires the seller to maintain a locking binder which contains copies of the warranties for the products sold in such department. The seller is required to display the binder in a manner reasonably calculated to elicit the attention of the prospective buyer. The seller must not remove the warranty prior to sale, and the seller must provide all warranty materials required by the Warranty Act.

Full And Limited Warranty: The Warranty Act requires that every written warranty be designated as "full" or "limited". A warranty which meets the federal minimum standards must be conspicuously designated as a "full" warranty and state its duration. A warranty which does not meet the federal standards must be conspicuously designated as a "limited" warranty.

The federal minimum standards essentially require that the warrantor:

1. Must remedy the consumer product within a reasonable time and without any charge;

2. Must not impose any limitation on the implied warranties;

3. May not exclude or limit consequential damages for breach of any written or implied warranty unless such exclusion or limitation appears conspicuously on the face of the warranty;

4. Must permit the consumer to collect a refund or replacement without charge if the product contains a defect or malfunction and the defect or malfunction is not corrected after a reasonable number of attempts.

The performance of these duties, however, shall not be required if the warrantor can show that the defect or malfunction was caused by damage while the product was in the possession of the consumer. The Warranty Act does not prohibit the selling of a consumer product which has both full and limited warranties if such warranties are clearly and conspicuously differentiated.

Disclaimer of Implied Warranties: The practice under the FTC Code of giving an express warranty and simultaneously disclaiming implied warranties has had the effect of limiting the rights of the consumer. The Warranty Act, therefore, is designed to limit this practice by providing that no supplier may disclaim or modify an implied warranty:

1. If he makes a written warranty;

2. If he, at the time of the sale or ninety days thereafter, gives a service warranty with respect to the product.

It is further provided, however, that implied warranties may be limited in duration to the duration of the warranty or of a reasonable duration provided such limitation is "conscionable and is set forth in clear and unmistakable language and is prominently displayed on the face of the warranty".

The disclaimer provision of the Warranty Act will prevail over the "Exclusion of Implied Warranties" of the FTC Code and any other contradictory state law which does not give the consumer greater rights. The state laws, therefore, will control to the extent that the state laws give greater remedies than those given by the Warranty Act. It should be kept in mind, however, that the disclaimer provisions in the Warranty Act apply only to consumer products costing $15 or more.

WARRANTIES AND SOLAR ENERGY SYSTEMS

The solar equipment manufacturing industry unfortunately includes several small suppliers having practically no experience with solar equipment and offering no warranties of any kind. Purchasers of such equipment have very little chance of reimbursement for costly failures. Even if a small, marginal manufacturer offers some sort of warranty, a purchaser does not have much assurance that the manufacturer will remain in business long enough to make good on its guaranty. In the event of equipment defect or failure, the owner (or contractor if an installation guaranty was provided), would suffer the loss. The issue of warranties and solar energy systems encompasses three related subject areas: marketing, guarantees, and consumer information.

Marketing Solar Systems

The Federal Trade Commission (FTC) is one of the most powerful and activist regulatory agencies in the federal government. Its actions have in the past and will continue in the future to affect virtually every consumer and corporation in the United States. It is a prosecutorial agency by nature, seeing its proper role as an enforcement agency designed to eliminate unfair or deceptive acts and practices and unfair methods of competition by seeking out those individuals and corporations it deems are violating federal law and taking action either in the form of a complaint and costly litigation against an individual company or "rulemaking"proceedings against an entire industry. The FTC focuses a considerable amount of its efforts upon the solar energy industry, particularly in relation to advertising and sales representations. Furthermore, since lack of knowledge concerning FTC requirements and lack of intent to misrepresent or in any way to violate the Federal Trade Commission Act will not forestall FTC action, it is essential that each advertiser be acquainted with at least the basic principles of FTC advertising law.

Two immediate areas that must be approached with a great deal of caution are advertising and sales representations related to (1) proposed tax cresits, and (2) savings to be expected from solar installations. Reliance upon tax credits, until actually enacted into law, should be avoided. Savings claims must be carefully and accurately stated and based upon full substantiation in the possession of the individual making the claims.

Deceptive Advertising: Unfairness or deception in advertising is a possibility in nearly any business. Inadvertent violations of the Federal Trade Commission Act in terms of advertising and sales representations can and do occur and have been committed by businessmen who did not intend to engage in misleading advertising and who, in fact, may have had no knowledge whatsoever that the advertising questioned was, or could be viewed as, deceptive. Neither good faith, lack of bad intent nor lack of actual knowledge of falsity of an advertisement are relevant to the question of whether an advertiser will be charged with a violation of the Federal Trade Commission Act. In other words, an advertisement or sales practice may be challenged as deceptive and may result in an FTC investigation, complaint and cease and desist order, even if the advertiser can conclusively show that he did not intend to mislead or deceive the consumer and that he had no knowledge or reason to believe that the advertisement in question could be viewed as deceptive. At the same time, voluntarily discontinuing a challenged practice or advertising claim before learning that the FTC may consider it to be deceptive or promising to discontinue the particular practice or claim after it is challenged cannot be expected to deter formal FTC action.

An advertisement may be viewed as deceptive and in violation of the FTC Act if it has only the "capacity" or "tendency" to deceive. Actual deception need not be proved or found by the Commission. There is no hard and fast rule for determining what is an "unfair or deceptive act or practice" or what is a "false advertisement". In exercising its expertise to determine whether a challenged advertisement has the tendency or capacity to deceive the public, the FTC assesses the meaning the public will give to the advertisement. This assessment is based upon the presumption that the general public, as a group, is not well educated or highly sophisticated and does not carefully study the language of an advertisement. In determining whether a repr esnetation is deceptive, the entire advertise ent is taken into consideration by the FTC. If a word, term, or sentence is ambiguous, and one meaning is false, the word, term or sentence is held to be deceptive. Literal truth is not a defense. That is, even if each sentence contained in an ad, standing alone, can be shown to be truthful, the advertisement will be found to be deceptive if the entire advertisement creates an impression which can be misleading. Furthermore, not only what is said in the advertisement, but what is not said, may constitute a deceptive act. Representations which are too broad to be generally true or which fail to disclose material facts which can affect the consumer's decision as to whether to purchase a product, should be appropriately qualified.

Advertising Product Test Results: Testing of the product and test results should not be claimed unless tests were actually made and were made on products which are representative of the product advertised. References to (1) standards utilized for comparison purposes, and (2) test conditions should be included in the advertising of test results. A representation based on tests that do not conform to industry test standards should be accompanied by a disclosure that industry test standards were not used. This is particularly true where, even though products have been honestly tested, claims are made that the product will meet consumer standards where no industry-wide, generally recognized minimum test requirements are in effect. Also, even in situations where tests relied upon are legitimate, the failure to disclose any affiliations with or the identity of the testing facility may cause problems.

An advertiser must have in his possession, prior to the time a claim is made, a reasonable basis for any such claim. That is, the advertiser, in particular with regard to a claim which relates to safety, performance, efficiency or quality of a product, must have in his possession, prior to the time that claim is made, adequate substantiation to support the claim.

Advertising Tax Credits: As a general rule, solar product advertising should not contain any representations concerning tax credits for the purchase of solar products until any such tax credits are actually enacted into law. Any reference in advertising to consumers suggesting the possibility of tax credits is viewed by the FTC as virtually inherently deceptive since there is no certainty that tax credits will be enacted by legislative bodies.

Warranty Advertising: Warranty-related advertising should not be confused with the items that must be contained in the warranty itself. Generally, any warranty-related advertising should disclose:

1. The product or part of the product that is warranted;
2. The duration of the warranty (if a "lifetime" warranty and the "lifetime" is any other than that of the purchaser, the "life" referred to should be disclosed);
3. What, if anything, anyone claiming under the warranty must do before the warrantor will fulfill his obligation under the warranty, e.g., return of the product or payment of service or labor charges;
4. The manner in which the warrantor will perform, e.g., repair, replace or refund;
5. The identity of the warrantor;
6. Whether the warranty is "Full" or "Limited".

Guarantees For Solar Systems

The types of warranties (guarantees) offered by manufacturers of solar heating equipment vary considerably. At the present time, if a supplier provides any warranty, it is of the "limited" type. Under its terms, the equipment is warranted to be free of defects in materials and workmanship, and that, if such defects are found within a certain period of time after initial use, correction or replacement will be made without cost to the user. A number of suppliers of solar equipment do not currently offer any type of warranty. A few larger companies involved in solar equipment manufacture are offering one-year limited warranties. One company marketing swimming pool systems offers a 10-year limited warranty as shown in the accompanying example.

There appears to be no manufacturer's guaranty as to thermal efficiency or heat delivery capability of solar equipment. Although manufacturers are providing that type of information in their sales literature, they are not guaranteeing the performance in the field. To a certain degree, this omission is due to the inability of the manufacturer to control the quality of the installation. In addition, manufacturers supplying only certain components of a system, such as the collector, cannot be assured that the other components in the system are correctly selected or integrated with their own product. Thus, inferior performance might well be due to factors other than those controlled by the collector manufacturer. A performance warranty would thus be difficult to establish and maintain.

Still another problem in providing a meaningful performance warranty is the great variation in climate encountered and the practical difficulty in accurately measuring the output of the installed equipment. Instrumentation is usually not provided, so measurement of performance is likely to be an expensive investigation by an experienced engineer. Disputes, litigation, and other problems are inevitable.

Practical performance warranties should become available for complete solar heating systems provided by a single manufacturer when assembled and installed by a single responsible individual or firm. Under such conditions, the manufacturer has sufficient control of the system design and the quality of the installation to have assurance of performance. The manufacturer could then guarantee the system to the installing firm which, in turn, would guarnatee it to the purchaser. In case of dispute, the installer could measure system performance in the presence of the owner and a third party, if demanded for determination of conformance. If inadequacies are determined, corrections would be made in compliance with the warranty, and the installer and manufacturer would establish responsibility for the departure from specifications.

Such developments as the Home Owners Warranty (HOW) program, sponsored by the National Association of Home Builders, can be expected to have an influence on solar heating equipment guarantees. Under the HOW program, all defects in a residential structure will be corrected at no cost to the owner during the first three years of use. It may be expected that solar heating equipment will have warranties conforming with such a program. Manufacturers will then be required to guarantee to the dealer and installer the necessary support for compliance with this program.

Consumer Information

Many homeowners are not interested in the mechanical operation of a solar system any more than they are about the mechanical operation of a car. However, some homeowners will be interested in complete details of the system. The contractor will have to decide, perhaps from the questions asked, just how much explanation of the system is necessary.

Also, the Consumer Product Safety Act of 1972, in addition to emphasis on the design and marketing of unsafe products, also stresses that essentially hazardous products must be properly labeled and full and complete instructions provided. The Consumer Products Safety Commission has stated "They (manufacturers, wholesalers, and dealers) must be in a position to advise the buyer competently on how to use and how to maintain and repair the product (sold)."

Servicing The System:

When the contractor leaves the job, the structure owner must be left with a system in which the components are clearly labelled. The operating procedures and maintenance recommendations must be fully identified. The safety and/or health hazards must be defined and, where necessary, prominently displayed. The components must be accessible and servicable by qualified service personnel. Such service should be possible with the installer/owner manual and a minimum amount of special tools. All maintenance and repairs should be possible without the need to dismantle a major part of the system. Standard labels or labelling techniques have not been developed as yet, however, as a guide, the following information could be included in an owner's manual:

1. The component name and part number;
2. The function of the component in the system;
3. The operating pressures and temperatures;
4. The direction of flow;
5. Safety or health hazards;
6. Trouble symptoms;
7. Maintenance schedules;
8. Service notes.

Writing An Owner's Manual: The owner's manual can take several forms. It can be as simple as a dozen or so typewritten sheets or as comprehensive as a notebook with detailed literature on each component in the system. With more and more standardization in the types of solar systems being installed, the owner's manual may easily become a personalized booklet issued by the contracting firm to support its system.

An owner's manual is not only important to the system owner. The contractor benefits because such a manual will most likely discourage unnecesary system tampering and, possibly, reduce the number of callbacks for unnecessary inspection or service. A knowledgeable owner will often detect minor problems before they become serious.

The information that goes into an owner's manual is up to the contractor. However, such a manual may soon become a standard requirement in the solar industry. As a guide, the following information could be included:

1. Installation instructions;
2. Start-up instructions;
3. Operating instructions;
4. Maintenance instructions;
5. Safety precautions;
6. Warrantee information;
7. Component manufacturers' names and addresses;
8. Sources for repair parts;
9. System schematics, complete with operational descriptions.

Defining Safety And Health Hazards: The installed solar energy system should pose no undue hazards to the building's occupants or to service personnel. As a general rule, components must be installed in a manner which precludes falling, tripping, or bumping by anyone working or living with the system. In addition, adequate protection against fire, burns, leakage, and corrosion should be provided. Most important, any and all potential safety or health hazards should be clearly defined. Each hazard should be pointed out in the owner's manual. Where possible, certain hazards should be noted on the component labels or as separate caution labels in key areas of the system. Examples of possible hazards which should be considered include:

1. Fire, from combustible liquids or solids;
2. Burns, from heated pipes and tanks;
3. Ruptures in pipes, from excessive temperature or pressure;
4. Growths, from molds, mildew, fungi or bacteria;
5. Contamination, from the mixing of potable water with heat-transfer liquid;
6. Infestation, from vermin or rodents;
7. Building materials decay, from moisture leakage or corrosive action.

'SURE AS THE SUN RISES'

* TEN-YEAR LIMITED WARRANTY *

Fafco, Inc., warrants each new swimming pool solar collector manufactured by it to be free from defects in material and workmanship under normal use for the purpose intended for a period of ten (10) years from the date of delivery to the purchaser; provided however, that installation shall have been made in accord with Fafco, Inc.'s instructions and procedures and that said products have been used solely for the heating of a swimming pool.

The sole obligation of Fafco, Inc. under this warranty is expressly limited to repairing or replacing any collector returned to it at its plant within the warranty period, transportation and insurance prepaid, and which its examination discloses to its satisfaction is defective, subject to the terms and conditions set forth below.

Such repair or replacement is expressly conditioned upon the purchaser paying to Fafco, Inc. the difference between (a) Fafco, Inc.'s suggested retail price for such collector at the time of the warranty claim is made, and (b) the prorated portion of Fafco Inc.'s suggested retail price for such collector at the time of the original purchase, in accord with the following schedule:

Year of Claim	Percent of Original Suggested Retail Price Credited Toward Repair or Replacement
First Five Years	100%
Sixth Year	75%
Seventh & Eighth Year	50%
Ninth & Tenth Year	25%

Fafco, Inc., shall notify the purchaser of any additional charges for the replacement or repair of the defective collector under the above schedule and upon receipt of the sum specified along with the costs of shipment and insurance, Fafco, Inc. shall repair or replace the collector and return it to the purchaser. Such repair or replacement shall not include the costs of disassembly, removal or reinstallation of the collector or any other services involved, and Fafco, Inc. shall not be liable for any of such costs or charges.

This warranty shall not apply to any collector which has been repaired or altered by anyone other than Fafco, Inc., or a person authorized by it, or to any collector which has been subject to misuse, neglect or accident, or which has been damaged by freezing, wind, hail, or by any other cause, thing, person, or act of God.

Fafco, Inc. makes no warranty as to the performance of its solar collector as to any particular temperature or level to which the water will be heated, since this depends upon the amount and intensity of sunlight and other variable factors which are impossible to predict and which cannot be controlled.

It is expressly agreed and understood that Fafco, Inc., merely manufactures the swimming pool solar collector and that for proper operation, said collectors must be installed by qualified, and competent personnel. While Fafco, Inc., warrants said collector as stated, it has no control over, or responsibility for how said collector is installed or local conditions existing at the time of installation.

This warranty is expressly exclusive and in lieu of all other warranties and guarantees, either express, implied or statutory, and all other obligations or liabilities of or remedies against Fafco, Inc. including any warranty of merchantability or fitness for a particular purpose. In no event shall Fafco, Inc., be liable for lost profits, injury to goodwill, or any other special or consequential damages.

This warranty is not transferrable, and is limited to the original consumer purchaser.

FAFCO, INC., 235 Constitution Drive, Menlo Park, California 94025

FAFCO

LIMITED TEN YEAR WARRANTY
BY FAFCO INCORPORATED (FAFCO)

1. SCOPE OF COVERAGE
   This warranty applies only to new swimming pool solar collectors manufactured by FAFCO and installed on premises owned by the original consumer buyer.

2. IDENTITY OF WARRANTOR AND WARRANTEE
   The warranty is extended by FAFCO to the original consumer buyer of the solar collectors and is not transferrable.

3. FAFCO'S WARRANTY
   LIMITED TEN YEAR WARRANTY: The FAFCO solar collectors are warranted to be free from defects in materials and workmanship under normal use and service for the heating of a swimming pool for ten (10) years from the completion of initial installation, subject to the terms, conditions and limitations described below.

4. WHAT IS NOT COVERED
   A. EXCLUSIONS: The above warranty does not apply to the following conditions or circumstances:
      1. To conditions resulting from any significant departure from FAFCO's installation instructions.
      2. To conditions resulting from failure to provide reasonable and necessary maintenance in accordance with FAFCO's operating and maintenance instructions.
      3. To conditions resulting from repair or alteration by anyone other than FAFCO or a person duly authorized by FAFCO to do such repair or alteration.
      4. To conditions resulting from misuse, neglect, or accident, or which result from freezing, wind, hail or by any other exposure to the elements, including fading and minor deterioration.
      5. To conditions not involving defects in material or workmanship except as otherwise explicitly covered by such warranty.

   B. NO WARRANTY OF PERFORMANCE OF THE SOLAR COLLECTORS AND SYSTEM
   FAFCO makes no warranty as to the performance of its solar collectors and system as to any particular temperature or level to which the water will be heated, since this depends upon the amount and intensity of sunlight and other variable factors which are impossible to predict and which cannot be controlled.

   C. LIMITATIONS ON EXCLUSION FROM COVERAGE
   The above warranty shall not be considered to be violated or its coverage in any way reduced, by conditions that may occur in the normal operation of the system.

5. SOME THINGS THE BUYER MUST DO
   A. PROPER INSTALLATION
   It is strongly recommended that the installation be made by a duly authorized FAFCO dealer or distributor. Should you, the consumer buyer, decide to do the installation yourself or employ a person not authorized by FAFCO, it is your responsibility to ensure that the installation has been made strictly in accord with FAFCO's instructions and procedures and complies with local laws, procedures and ordinances. It is also your responsibility to inform FAFCO in writing of the date of installation.

   B. ROUTINE MAINTENANCE AND CARE
   You are required to provide reasonable and necessary maintenance and care in accord with FAFCO's operating and maintenance instructions.

   C. KEEP FAFCO INFORMED
   If it appears that any warranted solar collector is not functioning properly, promptly notify FAFCO or FAFCO's authorized dealer or distributor in your area. Early attention to a minor problem may help avoid a serious problem later.

6. WHAT FAFCO WILL DO

A. REPAIR OR SERVICE

If a defect in material or workmanship becomes evident during the warranty period, FAFCO will repair, or at its option, replace the malfunctioning solar collector with a new or factory rebuilt solar collector of at least the same quality, within a reasonable time, upon payment of the charges described below.

B. WHO WILL PROVIDE WARRANTY SERVICE

Service will be provided by FAFCO's authorized dealer or distributor in your area. If there is no authorized dealer or distributor in your area, or if the installation was made by you or a person not authorized by FAFCO, then notify FAFCO directly at 235 Constitution Drive, Menlo Park, California 94025, Telephone: (415) 321-3650, giving the identification of the solar collector, the date of purchase, the date of installation and the nature of the defect or problem. To verify that your warranty is still in effect, you should be prepared to furnish evidence of purchase and the date of installation.

C. ON SITE DIAGNOSIS

If practical, FAFCO, or a person designated by it, or the FAFCO dealer or distributor who installed the system will inspect the warranted solar collectors at the site, upon payment of the reasonable costs of such inspection.

D. CHARGES FOR REPAIR OR REPLACEMENT

To obtain repair or replacement of the defective solar collector under the warranty, you are required to pay the difference between:

a. FAFCO's suggested retail price for the solar collector at the time the warranty claim is made, and

b. the prorated portion of FAFCO's suggested retail price for the solar collector at the time of the original purchase, in accordance with the following proration schedule:

Year of Claim	Percent of Original Purchase Price Credited to Repair of Replacement
First Five Years	100%
Sixth Year	75%
Seventh and Eighth Years	50%
Ninth and Tenth Years	25%

If possible, the repair or replacement will be made by FAFCO's authorized dealer or distributor in your area. Otherwise, the solar collector must be returned for warranty service to FAFCO at its plant, 235 Constitution Drive, Menlo Park, California 94025, transportation and insurance prepaid. Upon receipt of the defective solar collector, FAFCO will promptly notify you of any charges for repair or replacement, plus the costs of transportation and insurance to return the collector to you. Upon payment to FAFCO, it will repair or replace the defective solar collector and return it to you.

IN ADDITION TO THE CHARGES FOR REPAIR OR REPLACEMENT OF THE DEFECTIVE SOLAR COLLECTOR, YOU ARE RESPONSIBLE FOR THE PAYMENT OF ANY COSTS AND EXPENSES OF DISASSEMBLY, REMOVAL AND RE-INSTALLATION OF THE SOLAR COLLECTOR, AND ANY OTHER SERVICES INVOLVED. NONE OF SUCH COSTS OR EXPENSES ARE COVERED BY THIS WARRANTY, AND FAFCO IS NOT LIABLE FOR ANY OF THEM.

7. NO OTHER WARRANTIES – THESE REMEDIES ARE EXCLUSIVE

Unless otherwise explicitly agreed in writing, it is understood that this is the only written warranty given by FAFCO and FAFCO neither assumes nor authorizes anyone to assume for it any other obligations or liability in connection with its products. In no event shall FAFCO be liable for damage to property, lost profits, injury to goodwill, or any other special or consequential damages resulting from any defective solar collector or any breach of the above express warranty. Some states do not allow the exclusion or limitation of incidental or consequential damages, so this exclusion or limitation may not apply to you. The above warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

FAFCO, INC., 235 Constitution Drive, Menlo Park, California 94025

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CODES, LEGALITIES, CONSUMERISM AND ECONOMICS

THE CONTRACTING SYSTEM

STUDENT MATERIAL

CODES, LEGALITIES, CONSUMERISM AND ECONOMICS

THE CONTRACTING SYSTEM

The contracting system addresses consumer issues, contractor issues, and the interrelationship between the two.

CONSUMERS AND CONTRACTORS

One day it happens, you the consumer, need to remodel. You know that remodeling requires experience, skills and compliance with building codes -- so it's not a do-it-yourself proposition. You check the bank balance, estimate that the family budget will allow for some expenditure on home improvement and decide to have the job done. Should you get on the phone right away and start calling local contractors? Absolutely not. It's not enough, for instance, just to know that you want to remodel a kitchen or add a family room. You also have to know, among other things, how much you are willing to spend, what style addition you would like, how much equipment you want to replace, and what purposes the new space or new arrangement should serve. No matter what kind of a remodeling job you are planning, however, visits to local appliance stores, home equipment showrooms, home decorating centers, and lumberyards will give you some background on the kind of equipment and materials available, their cost and what installation problems may arise. This information will also help you to estimate what your budget will bear and to appraise the expertness of the contractors you deal with.

Can the building owner install a solar energy system? The answer is "yes"; however, it is a qualified yes. The building owner can install a solar energy system; but the owner must have the proper mechanical skills. The owner must be willing to make the necessary educational investment. The owner must be willing to utilize engineering consultant services as needed. And, the owner must be willing to purchase the necessary tools and equipment. However, as the contractor, the owner assumes any and all risks involved in purchasing and installing the solar equipment. Errors in judgement or construction may turn into costly mistakes. Most building owners will therefore elect to hire a qualified contractor. The investment in time and money for a good system often necessitates this decision.

What follows is a complete step-by-step checklist for all the major areas where it may be necessary to subcontract the various construction operations for a typical single-family house.

Review the items carefully and then decide how much of this work you wish to take on and how much to delegate to a contractor.

ITEM	COMPLETED
1. Financial arrangements (loan or other	
2. Building permit	
3. Drill well or obtain city water connection permit	
4. Septic system permit (from health department) or sewage connection permit	
5. Installation of septic system--generally required to be done by professional; may also be installed last	
6. Temporary electric service (by electrician) or portable generator	
7. Job phone (optional)	
8. Excavation contractor (may be done by hand on pole houses)	
9. Masonry contractor (if you use a masonry foundation)	
10. Concrete finisher or rent troweling machine (if you use slab construction)	
11. Materials for shell of house (furnished by contractor or owner?)	
12. Carpenter/contractor to build shell (should include windows, exterior doors and roof)	
13. Installation of rough wiring	
14. Installation of rough plumbing	
15. Inspection of above work if required by code; notify inspector(s)	
16. Install insulation (easy to do-it-yourself)	
17. Install finish siding	
18. Install sheetrock	
19. Finish electric wiring and plumbing	
20. Inspection for above if necessary; notify inspector(s)	
21. Finish carpentry--shelves, hang doors, install trim, finish floors, etc.	
22. Spackle sheetrock and paint interior	
23. Backfill and finish grading (may not be necessary for pole house)	
24. Get occupancy permit from building inspector, if necessary	

Your next, and most important, step is to find a reliable contractor. Even though the need seems urgent, this is not the time to settle for any contractor who promises instant dream kitchens, playrooms and bathrooms. You're about to make a big investment in money, time and household disruption -- and if you make mistakes you will probably have to live with them for a long, long time.

The planning branches of building-construction work include the services of architects, engineers, and contractors. Other branches of the building trades include excavation, or the digging of foundation pits and tunnels; structural-steel erection, sheet-metal work, masonry, or the construction of brick, concrete, or tile structures; glass installation; woodworking, roofing; painting and decorating; and the mechanical trades, which include the installation of electrical, plumbing, heating and ventilating equipment. A building or other construction project may be erected by an individual or an organization that makes the plans, hires the laborers, and buys the materials directly. Most construction work, however, is turned over to a general contractor. The contractor agrees, in a written bid or proposal, to complete the building according to the plans and specifications of an architect. The price may be a fixed lump sum, or the contractor may agree to construct the building for whatever it costs plus a fixed fee, or a percentage, of the building cost. The general contractor may do all or a large part of the work under the contract. Usually, however, he makes use of subcontractors, who furnish the labor and materials for certain parts of the work, such as the excavating, carpentry, bricklaying, plastering, or plumbing. The subcontractors also receive a fee or percentage for their part of the work.

If there is one characteristic consumers have in common, it is the desire to get one's money's worth on a commercial transaction. In the solar field, there are three main obstacles in satisfying this all-important objective:

1. The consumer's own lack of knowledge and inexperience in this field.

2. Manufacturers who unintentionally build shoddy products and who are too overenthusiastic about their products.

3. Deliberate fraud and misrepresentation.

The best weapon against all three is for the consumer to recognize his or her own limitations and to rely upon competent engineering counsel. "Knowing that one does not know" is the first step toward wisdom, as one old philosopher said.

In order to have a successful relationship with a contractor you must:

1. Check him out, and
2. Make him bid competitively; then
3. Enter the contract in good faith, remembering this:
4. Don't overpay him during construction, and
5. Keep a written record of everything.

There's a lot more, of course: insurance coverage, guarantees, contract terms -- but if you follow the five basic rules you'll probably have little trouble.

Reliable Contractors

What makes a contractor reliable? Many things. He has been in business long enough to have established himself as responsible and trustworthy. He has a crew of subcontractors and workmen whose work and dependability he is sure of. (Most contractors are small-business men, who subcontract parts of the job, such as the carpentry, the painting or the electrical work.) He knows the state, county and local laws that regulate rebuilding and remodeling and will make sure that your job, when finished, conforms with all these regulations. He carries insurance covering workmen's compensation, property damage and personal liability and can provide you with a certificate of insurance to show his coverage. He will maintain a maximum of cleanliness and order on the job. There is one thing a reliable contractor will not do, however. He will not give you a firm date on which the job will be finished -- and with good reason. He knows that it is almost impossible to estimate exactly how long a job will take, and what unforeseen problems may be encountered along the way. He is dealing with independent craftsmen who are in diminishing supply, and he can't be sure that they will always adhere precisely to his schedule. And he must allow for factors beyond his control, such as delays in delivery, bad weather and illness. So he will probably be able to give you only a tentative completion date. But he will try to keep to it, not only because he wants to please you as his customer, but also because it is to his advantage to finish as quickly as possible so he can collect his money and start on a new job. If he is experienced and reliable, moreover, he will not take on more work than he can reasonably handle.

In spite of all the negative things we all hear about the construction industry and its notorious little brother, the home improvement business, most contractors are fairly honest, reasonably dependable, and interested in doing a good job. They're also interested, of course, in making money. Like the rest of us, they're still a bit spoiled from having had a twenty-five-year free ride between 1950 and 1975, but, now that the great building boom has subsided, they're learning to give better value for each dollar. Every reputable contractor will give you the names of his most recent customers. But if you fail to follow through and only pretend to check his references you'll have no one to blame but yourself if things go wrong. Check not only his recent customers, but also his credit rating. Your bank can tell you how to do this; it's important. It really pays to find out what the recent customers of your contractor have to say. In order to hear what you need to hear, you'll need a sensitive inner ear. Be prepared, for instance, to hear some complaints about the guy, no matter what he's really like. You have to recognize comments like "The damned thing works all right, but he still hasn't taken all his cartons away" (even when such comments are delivered in the most outraged of voices) as being of a far different nature from this: "He never paid any of his suppliers and he hasn't come back for two months". All of us have weaknesses and strengths; nobody's perfect. Try to get a sense of how the contractor performs on the important items, and be flexible enough to live with some temporary frustrations on the others. After all, he may have some problems with you, too.

You can also form an opinion on your own by visiting the contractor's headquarters to see if he appears to be firmly established.

Occasionally you will find a contractor who is an absolute louse; someone who wants to do as little of your work and take as much of your money as he possibly can. If you get bad vibes from a person on first meeting him, be doubly careful. You weren't given your vibe-antennas for nothing. Sometimes, of course, you won't recognize a con man at first sight. That's why we added those rules about staying a little behind in you payments and keeping good records. Usually, however, all the warning signs are there before you sign on the dotted line -- if you're willing to recognize them.

Be careful of sellers who use Post Office Box numbers. Though many legitimate businesses use these outlets as a convenient way to receive bills and orders, a common tactic of the fly-by-night artist is to use a Post Office Box number, operate a territory until the law starts closing in, then move and take a new name in a new territory. Find out from the seller where his place of business is, how long he has been there, and ask for his financial references.

Buying A Solar System

Beyond the need for proper engineering counsel, there are some other steps you can take to insure that you get your money's worth in a solar system:

1. Ask for proof that the product will perform as advertised. The proof could come from an independent laboratory or a university. You should have the report itself, not what the manufacturer states the report claims. Have your engineering consultant go over the report.

2. Examine the warranty carefully. Remember that according to the law, the manufacturer must state that the warranty is full or limited. If it is limited, know what the limitations are. How long does the warranty last? Are parts, service, and labor covered? Who will provide the service? Does the equipment have to be sent back to the manufacturer for repairs? Make sure you understand the terms of the warranty before you buy. Ask the seller what financial arrangements, such as an escrow account, have been made to honor the warranties. Be sure your engineering counsel not only looks over the warranty, but the design itself to determine whether there are any important omissions.

3. Solar components are like stereo components -- some work well together, others don't. If the system you are purchasing is not sold as a single package by one manufacturer, then you should obtain assurance that the seller has had the professional experience of choosing properly.

4. Ask the man or woman who owns one. Ask the seller for a list of previous purchasers and their addresses, and then ask the owners bout their experiences.

5. Be sure you will know specifically who will service the solar system if something goes wrong. Don't settle for a response that any plumber or handyman will do.

6. Don't try a do-it-yourself kit, unless you really have a very solid background as a handyman. One or two mistakes could make a system inoperable and you will have no one to blame but yourself.

7. Remember that what counts with a solar system is the amount of Btu's delivered for the final end use of the system, and that this amount can fluctuate widely. A very good winter with much sunshine can produce performance levels beyond the manufacturer's projections. Conversely, an unusually bad winter with heavy cloud covers could make the projections drop dramatically. The seller will be working from historical averages.

8. Don't forget your local consumer office or your Better Business Bureau. Both may be able to help you determine whether a seller is reputable or not. Check, too, to see whether there is a local volunteer citizens solar organization around. If so, it can probably give you plenty of good advice.

9. If the seller makes verbal claims that are not reflected in the literature handed out, ask him to write those claims down, and to sign his name to it. Compare what he said with what he wrote; save that statement.

10. If you have what appears to be a legitimate complaint, notify the local district attorney's office immediately, the Better Business Bureau, and the local consumer protection agengy. Be as specific in your complaint as possible, and give as much documentation as you can.

Competitive Bids

Unless the contractor is your dearest friend -- or your own brother -- it's always wise to make him compete with others for the chance to do your work. In fact, even if he is your dearest friend, it's still not a bad idea. If your job is too small to attract competition, of course, you may have to take anyone who is available, but if your job is that small why aren't you doing it yourself? Competition is the backbone of the free enterprise system. When there is real competition the consumer is protected. When there is collusion -- when the bidding is rigged -- there is only charade. In order to be treated fairly by your bidders you must start by being fair yourself. Don't ask -- or allow -- anyone to bid unless he's someone to whom you'd be willing to award the job if his price were right. Contractors spend a lot of money preparing bids, particularly those which involve alterations to existing structures, and it is not right to ask for bids if your only motive is to sharpen the price of another contractor, one to whom you've already planned to award the contract. You may get away with it, but if the quality of human society continues to deteriorate you can no longer have the fun of blaming others.

On small construction contracts, bids are often called estimates, but an estimate is literally "a rough calculation", and rough calculations have a tendency to escalate when they're turned into smooth ones, so get written bids (firm prices) and try to make sure that all the bidders are bidding on identical, or at least comparable, systems. If one is bidding on Solarapex and another on Solaracme, you may not be able to make a wise decision. If each bidder is tied to a different solar supplier, then don't name any manufacturer or supplier when you ask for bids. Write what is called a performance specification, describing the kinds of materials and results you want, forcing each bidder to meet your specifications with his bid. Sometimes performance specs will name a manufacturer as an example of a company providing the kind of material or equipment you want. The name is, in that case, followed by the words "or approved equal". This is somewhat loose since there can be disputes over what is truly equal to what, but at least it's a guide to a general level of acceptability. Construction guatantees usually run for a year after final payment, or after completion of the work. Often, the individual components and equipment will carry longer guarantees or warranties. Here, with regard to competitive bidding, it's only necessary to remind you that the bidders must be told that among your requirements for the system is one stating that the solar contractor himself must guarantee all workmanship and materials for a full year. "But what if I don't know how to describe the system I want? How can I get competitive bids?" We often hear that kind of question and we always answer it the same way: If you can afford professional help, get it. Sometimes, an hour or two of mechanical engineer's, or a solar consultant's, time is all you'll need. Ask him first what his hourly rate is and then take advantage of it. But if you can't afford such services, or if, as it is to most people, the land of lawyers and consultants is a foreign one, then your best bet is to educate yourself, to read a book -- if you can handle the technical side of solar devices -- then write a brief description of the system you want. You have to strike a careful balance between scaring the contractor with overly technical and legalistic requirements, and inviting him to take you to the cleaners with overly loose ones.

"But what if I don'tknow how to describe the system I want? How can I get competitive bids? The following example may help.

John Butz, President
Solaracme Contracting Company
18 Main Street
Middleville, IL

Re: Request for a Bid on a
Solar Heating System for the house of
Elizabeth Jones
421 Center Street
Middleville, Illinois

Dear Mr. Butz:

During the winter of 1977–1978 my total heating bill was $827.20. I believe my house is suited for solar heating. If you are interested in providing it with a solar system will you please send me a bid for the work? I must have your proposal no later than September 21, 1978. Here's what I want:

> An air system with fully watertight and airtight rooftop collectors of at least 400 square feet, forming with the roof a permanently weatherproof structure, and having an insulated rock bed storage unit in the basement, complete with all ducts, controls, parts, and connections to my present heating system as needed to reduce my heating bill (for a winter equivalent to that of 1977–1978) by 60%. It is important to me that all parts of the system be selected for low maintenance, resistance to corrosion and leakage, ease of operation, and high efficiency.
>
> In addition, I want you to provide a separate, liquid-type solar preheating system for my domestic water heating system, using copper for all parts having contact with water or the collector liquid. Include provisions for easy filling of the system, and a reserve tank into which it can be drained. This system must have its own collectors of at least 35 square ft. and a thoroughly insulated solar-heated domestic water storage tank of 80-gallon capacity, providing all work needed for a complete system.

Please name in your proposal the manufacturers of all major components.

I look forward to your response on September 21.

Sincerely,
Elizabeth Jones

When you have satisfactory proposals from several (if you are fortunate) reputable contractors you will have to choose among them. How should you make the choice? Though it may seem thrifty, the lowest bid is not necessarily the best. The contractor may have underestimated the time and work involved, and may cut corners later trying to make up for his mistake. Moreover, if he is losing money on your contract, he may give a higher priority to more profitable jobs, and your work will drag on and on. One building expert puts it this way: "Many times what you are paying for in a bid is experience. Most remodeling jobs are done on older houses, and the experienced contractor knows that he is almost sure to run into problems that cannot be foreseen, but must be allowed for. In older homes it is not unusual to find walls several feet thick, gas pipes left over from the days of gas lights, rotting timbers and other unexpected difficulties." This does not mean, however, that the contractor who submits the highest bid is necessarily the best -- he may simply be the most expensive. There are no firm rules on how to make this decision; you will have to rely on the contractor's reputation, your own judgment based on your dealing with him and a little bit of luck. One word of caution: Don't tell one contractor what another one has bid or you may unwittingly cause the second bidder to ask a higher price than he had intended.

Contractors' proposals are often presented on forms which, when signed, become contracts. Just be careful to see that the terms are fair. More often than not, such care will result in the writing of a new proposal, inasmuch as your review of a proposal and subsequent meeting with the contractor, will undoubtedly result in new understandings and modifications which will require a rewriting of the original submission.

Contract Terms

There's a whole world of potential legal problems in a construction contract. The easiest procedure, of course, if you can afford it, is to hire professionals for every step of the process -- a solar specialist/mechanical engineer to design the system and administer the construction of it, and a lawyer to handle the contracts and other legal matters. Where a lot of money or complications are involved, that is the only procedure to follow, but on most home solar installations it is not necessary.

Once you have satisfied yourself about the reputability of several local contractors, you're ready to call one or more to visit your home and discuss the job that you're planning. This first appointment is always on the contractor's time -- it's an investment he makes in the hope that he will get the job. Though he expects to invest this time, the more businesslike and informed you are, the more satisfactory the meeting will be. This is the moment when the "homework" you have done --on plans, materials and appliances--will begin to pay off. Though you are wise to start with some of your own ideas, don't ignore suggestions and advice from the contractor. He has had experience with remodeling problems, with various materials, with different appliances, and is in a position to give you good advice. Sometimes he may be quite right in saying a material or an appliance is not suitable for the purpose you have in mind, or has not held up as well as it should, or is more expensive than another brand that will serve exactly the same purpose. But he may also suggest an alternative simply because he gets a better discount on it or because it's easier to work with. You will have to use your own judgment. If you are in doubt about a material, however, and the contractor is reliable, it will probably pay you to go along with his suggestion. For a major remodeling job a good contractor will give you plans and insist that you approve them before he begins working. Study them carefully--it's easier and much, much cheaper to make changes in a plan than to wait until work is in progress and then decide you really wanted the door to be in the middle of the wall, not off to the side. If you do change your mind midway, there may be wiring or plumbing to be undone in addition to changes in the working drawings and the schedules of the workmen involved. All these things are time-consuming, and the contractor is perfectly within his rights in adding the costs of the extra time as well as additional materials onto your original bill. You'll want to check with the contractor to be sure that he is adequately insured and that he will provide all the permits required by your local building laws. Be sure, too, that your agreement has a written provision freeing you from liability if the contractor goes bankrupt before the job is finished. Under existing mechanic's lien laws, you can be held liable for payments on materials and labor on your remodeling job--even though the material or the workmen were to have been paid by the contractor--unless your agreement specifically protects you against such liens.

Another important part of your agreement is how and when you pay. The contract should state specifically the scope of the work to be done and how much it will cost. It is customary for the contractor to get a down payment, about 10 to 15 percent of the finished price, before he begins. The remainder is paid when the job is completed. On a very large job the contractor may specify progress payments, but this is less customary. If there is such a clause in your contract, be sure it provides for some relationship between the progress of the work and the amount of payment to be made.

You will also want to give some thought to the guarnatees on the materials and appliances you are getting. Usually they are given not by the contractor, but by the suppliers or manufactureres. In any case it pays to find out what you can expect of the materials being used, and where you can complain if something proves defective. The Fair Trade Commission has set up guidelines on some materials that the contractor should know and tell you about. Roofing and siding materials, for instance, can only be guaranteed for 15 years, and anyone who guarantees them for longer is either misinformed or trying to mislead you. For appliances such as air-conditioners, find out if there are local service offices so that you can get repairs or replacement parts quickly if needed, and ask the contractor what experience he has had with the service organization. When it comes to the installation of plumbing, heating systems and water heaters, find out whether the contractor or the subcontractor is going to be responsible if something goes wrong after the job is completed. Get written guarantees.

You might also ask the contractor for the name of the supply house that will provide the material for the job. Then you can check to be sure that he has ordered what is specified in the agreement. If you find out that the supplier will deal with the contractor only on a cash-on-delivery basis, proceed with caution--a man with a poor credit rating may not be a good risk.

Find out also about cleaning up and removing debris. A good contractor will clean up as he goes along, but there are bound to be some materials left over when the job is finished. Most contractors offer a clause in their contract that guarantees they will leave your house and premises "broom clean". There may be a charge for this, but it could be well worth it to be spared the annoyance and expense of getting rid of the debris yourself.

In the language of construction, one good word to remember is "provide". Make it clear that you want the contractor to do more than simply furnish--or install--the work. You might even write that into the contract--that he is to provide a complete, functioning, fully guaranteed system. A nice, big general catchall like that may get you into less trouble than will a long and detailed spec to which you may have failed to add a crucial clause.

The Written Agreement

The contract--Get it all in writing.

Examine the written contract carefully and make sure all promises are in writing: work to be done, quality of materials, total cost, completion time, performance claims. Take your time and know what you are signing: read and keep a copy of all papers.

Some suggestions:

1. Get all details and claims in writing on the contract; use advertising claims and brochures as exhibits or attachments to the contract.

2. Read and understand the contract; make sure every blank is filled in properly and completely.

3. Be sure there is a detailed description of the job to be completed; make sure it includes the specifications with the brand name and size of the materials.

4. Spell out terms of the warranty clearly.

5. The schedule by which the contractor is to be paid should be defined.

6. Consider a contract with an incremental payment schedule, so you can pay only upon satisfactory completion of incremental "steps" of the job; withhold final payment until you are satisfied with the work.

7. To avoid getting sued if your contractor is uninsured, make sure the contractors and subcontractors certify in writing all damage, personal damage, and liability responsibilities. If they can't or won't do this, get another contractor. Most contractors are required to carry insurance; and many will provide you with a form from their insurance company telling you the job is covered.

8. Consider a "hold back" clause for 10 to 20 percent of the job cost. This allows you to delay the final payment until 30 days after the job is completed, so you can get corrections made. Beware of the contractor who wants a big payment of money from you before work is begun; some payment up front is common, but generally not more than 30 percent.

9. Consider a "broom clean" clause which makes the contractor responsible for clean-up and removal of all debris.

10. Specified payout schedule; banks provide this service for a small fee, sometimes very inexpensively if you take out a loan for the job. The banks also will take care of securing lien waivers, which may save you a legal fee.

11. Secure lien waivers. Under Colorado statute, and several other states as well, anyone who does work on your house and is not paid can place a lien on your home (i.e., claim part of your property if they have not been paid). Even if you paid the contractor, the subcontractors can place a lien against you if the contractor has failed to pay them. Lien waivers should be written into your contract.

12. Make sure the bid or estimate includes all costs, including labor and materials; get a fixed bid contract, if at all possible. If you must pay by the hour or some other way, put a maximum dollar ceiling in the contract.

13. Include a contract clause making the contractor responsible for meeting all codes, securing any required permits, and meeting any other laws or rules.

14. Always specify the starting and completion dates for the job; you can write in a penalty for failure to complete the job on time.

After you've chosen the contractor and an agreement has been put in writing, have it checked by a lawyer who has experience with such agreements, by your mortgage company or, if you have arranged for bank financing, by the home improvement loan department of the bank. When none of these checks is possible, read the contract carefully yourself.

Be sure, if you have been dealing with a representative of the contractor, that the name of the contractor, not the name of the salesman or the representative, is on the contract. Otherwise, you may find that the salesman has made promises that the contractor can disavow.

PROPOSALS

Pricing a solar energy system should include all materials, labor, subcontractor fees, engineering consultant fees, agreed upon warrantees and maintenance, start-up costs, call-back services, contingency fund, overhead, and profit.

The first time contractor must include some of the cost of manufacturer's technical service, standards development, possible installation school, instruction manuals, and learning new mechanical skills. Becoming a qaulified solar contractor involves time and money. Such an investment should be recovered by including a portion of the costs in the first few solar installations. These are reasonable costs.

Large or complex solar systems may require detailed structural calculations for collector racks and storage tanks. Such calculations should be done by a qualified professional engineer who is familiar with these types of structural requirements. Professional engineers are usually state-licensed and a list of names can readily be obtained.

Building alterations may be required to reduce infiltration, lower transmission losses, and prepare the structure to receive the solar collectors. These alterations may not be part of the solar system installation. They may not be the responsibility of the solar contractor. However, such alterations must be accomplished before going ahead with the job.

The job pricing therefore would typically include consideration of the following costs:

1. Education and engineering services
2. Building modifications
3. Materials for the collector loop
4. Labor for the collector loop installation
5. Materials for the storage system
6. Labor for storage system installation
7. Materials for the heat-delivery loop
8. Labor for the heat-delivery loop installation
9. Subcontracted services
10. Overhead and miscellaneous expenses
11. Reasonable profit.

The cost estimate is best approached by splitting out the labor, materials, and outside services; by doing so, the profit opportunity can be maximized. These costs and profits are best calculated in the sequence in which the material is used or the labor performed. This will allow you to know exactly where costs may be running high or low.

Engineering Services

A sample form for estimating engineering service costs is shown below. The form covers your costs, if any, for contrating with a design consultant or professional engineer. These services may or may not be required depending on the particular job. If they are required, the costs should be included in the job price.

SAMPLE FORM FOR ESTIMATING ENGINEERING SERVICES COSTS

ENGINEERING ITEMS	COST ESTIMATE	JOB PRICE
Solar Design Consultant.	____________	____________
Engineering Services		
Collector Mounting Foundations	____________	____________
Solar Storage Tank.	____________	____________
Other: ______________________________	____________	____________
______________________________	____________	____________
Total:	____________	____________

Spaces are given in the form for estimated costs as well as the quoted prices. Job price minus estimated cost equals the gross estimated profit. By splitting out the estimated profit on each item, you can plan the proper markup for that service.

Building Modifications

A sample for estimating building modification costs is shown in figure 20-2.

This form covers costs for collector array mounting foundations.

It also covers costs for building modifications to lower infiltration losses or transmission losses.

These costs may or may not be the responsibility of the solar contractor.

When they are, a job price needs to be calculated and included in the final solar system price.

Include the cost of supervising and inspecting the subcontractor's work, if you are responsible for such work.

Spaces are given for estimated costs as well as quoted prices.

Job price minus estimated cost equals the gross estimated profit.

By splitting out the estimated profit on each item, you can plan the proper markup for that material or service.

BUILDING MODIFICATIONS		
Item	**Cost Estimate**	**Job Price**
Collector Array Mounting Foundations		
• Design and Engineering		
• Drawing and Specifications		
• Materials		
• Site Preparation		
• Labor		
• Clean-up and Inspection		
Subtotal:		
Building Modifications to Lower Infiltration		
• Inspection and Recommendations...		
• Analysis and Quotations		
• Materials		
• Labor		
• Clean-up and Inspection		
Subtotal:		
Building Modifications to Lower Transmission		
• Inspection and Recommendations...		
• Analysis and Quotations		
• Materials		
• Labor		
• Clean-up and Inspection		
Subtotal:		
Other Required Building Modifications		
Subtotal:		
Total:		

Figure 20.2 A sample form for estimating building modification costs.

Collector Loop Materials Costs

The costs for the solar collector loop are best estimated in two stages: first, estimate the cost of materials; second, estimate the cost of installation labor.

A sample form for estimating the costs of collector loop materials is shown in figure 20-3.

This form is designed for use with a typical system.

The various parts of the collector loop are itemized, along with several optional parts, piping and fittings.

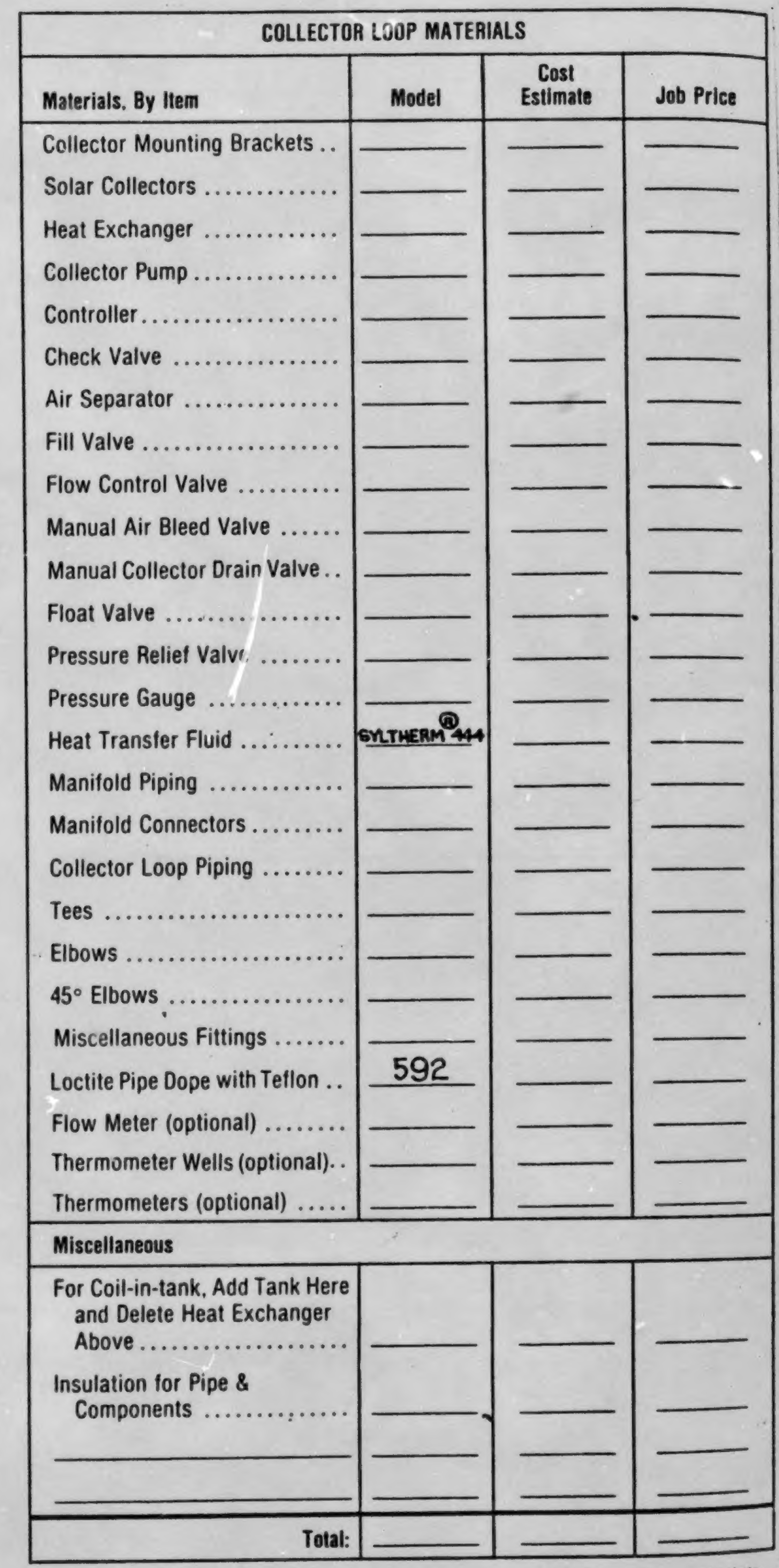
Spaces are given for part model numbers, the cost estimate, and the job price.

In using this form, remember that:

1. a separate form will be used for labor costs,
2. the collector mounting brackets may or may not be part of the collector price,
3. there is no external heat exchanger with a coil-in-tank system; instead, include the tank complete with its internal heat exchange coil.

Job price minus estimated cost equals the gross estimated profit.

By splitting out the estimated profit on each item, you can plan the proper markup for that material or service.



COLLECTOR LOOP MATERIALS

Materials, By Item	Model	Cost Estimate	Job Price
Collector Mounting Brackets ..			
Solar Collectors			
Heat Exchanger			
Collector Pump			
Controller			
Check Valve			
Air Separator			
Fill Valve			
Flow Control Valve			
Manual Air Bleed Valve			
Manual Collector Drain Valve ..			
Float Valve			
Pressure Relief Valve			
Pressure Gauge			
Heat Transfer Fluid	SYLTHERM® 444		
Manifold Piping			
Manifold Connectors			
Collector Loop Piping			
Tees			
Elbows			
45° Elbows			
Miscellaneous Fittings			
Loctite Pipe Dope with Teflon ..	592		
Flow Meter (optional)			
Thermometer Wells (optional)..			
Thermometers (optional)			
Miscellaneous			
For Coil-in-tank, Add Tank Here and Delete Heat Exchanger Above			
Insulation for Pipe & Components			
Total:			

Figure 20.3 A sample form for estimating the costs of collector loop materials

Collector Loop Installation Labor Costs

A sample for estimating the costs of collector loop installation labor is shown in Figure 20.4 (following page). The individual tasks are itemized to simplify the labor cost estimate. On this form you will:

1. Estimate the number of hours required to perform each installation task.

2. Multiply the time estimate by the hourly rate to determine the total direct cost.

3. Add the cost of insurance, taxes, and employee benefits.

4. Add the profit desired from the labor.

(The insurance, taxes, and employee benefits entry is actually an indirect cost, but for convenience is included on this form.)

Items that should be included in insurance and taxes are: workman's compensation, FICA (employer's share), unemployment taxes (federal and state), union dues, and inspection fees.

Items that should be included in the employee benefits package would normally include: health and life insurance, paid vacations, holiday and sickness allowances, bonus and pension plans, and any other employee benefits.

Any subcontractor's cost, such as a crane, should be transferred to the Subcontractor's Estimating Form, discussed elsewhere. Such a cost should not be included in the total for the labor estimate.

COLLECTOR LOOP INSTALLATION				
Labor Item	**No. Men**	**Hours**	**Labor Rate**	**Total Cost**
Transport collectors to job site				
Install collector mounting system				
Hoist Collectors				
(Subcontract Crane $ ________ Transfer to subcontractors form)				
Connect Collectors to Mountings				
Fabricate the Manifolds				
Pipe Collectors to Manifolds				
Pipe Collector Loop to Service Room				
Install Heat Exchanger (or coil-in-tank)				
Install Pump				
Pipe Collector Loop in Service Room				
Install Controller				
Inspect & Check Piping Loop Against Working Drawings and Specs				
Air Pressure Test Collector Loop				
Leak Repair Allowance				
			Subtotal:	
Fill Collector Loop				
Start-up & Check-out of Loop				
Set Loop Flow Rate (clear sky, noon)				
Insulate Loop Piping and Components				
Label & Indentify Loop Parts				
Type Instruction/Service Manual				
Paint & Clean-up				
			Subtotal:	
Insurances and Taxes				
Employee Benefits				
			Subtotal:	
			Profit:	
			Total:	

Figure 20.4 A sample form for estimating the costs of collector loop installation labor.

Storage System Materials Cost

The costs for the solar storage system are best estimated in two stages -- materials, then labor.

A sample form for estimating the costs of storage system materials is shown in Figure 20.5. This form can be used for the storage loop in a complete system, as well as for the storage loop in a water-heater system with an external heat exchanger.

STORAGE SYSTEM MATERIALS

Materials, By Item	Model	Cost Estimate	Job Price
Solar Storage Tank			
Solar Storage Tank Pump*			
Solar Storage Expansion Tank			
Drain Valve*			
Piping*			
Tees*			
Elbows*			
45° Elbows*			
Miscellaneous Fittings*			
Water Treatment Chemicals			
Water Test Kit			
Sight Glass (optional)			
Sensor Well (optional)			
Relief Valve*			
Insulation for Pipes and Components*			

*Use these items only for jobs that have a water heater with an external heat exchanger.

Figure 20.5 A sample form for estimating the costs of storage system materials.

Storage System Installation Labor Costs

A sample form for estimating the costs of storage system installation labor is shown in Figure 20.6. This form includes insurance and benefit provisions which are actually indirect costs, but are included here for convenience. Items that should be included in insurance and taxes are: workman's compensation, FICA (employer's share), unemployment taxes (federal and state), union dues, and inspection fees. Items that should be included in the employee benefits package would normally include: health and life insurance, paid vacations, holiday and sickness allowances, bonus and pension plans, and any other employee benefits.

STORAGE SYSTEM INSTALLATION

Labor Item	No. Men	Hours	Labor Rate	Total Cost
Install Solar Storage Tank; or				
Water Preheater Tank*				
Install Expansion Tank				
Install Pump*				
Pipe Loop*				
Connect to Auxiliary Heater/ City Water* (water preheater only)				
Insepct and Check Piping Loop Against Working Drawings & Specs				
			Subtotal:	
Fill Storage Tank*				
Treat Storage Water				
Start-up & Check-out Loop*				
Leak Repair Allowance*				
Insulate Loop Piping & Components*				
Label & Identify Loop Parts*				
Paint and Clean-up*				
			Subtotal:	
Insurance and Taxes				
Employee Benefits				
			Subtotal:	
Profit on Labor			Profit:	
			Total: (add 3 subtotals and profit)	

*Use these items only for jobs that have a water heater with an external heat exchanger.

Figure 20.6 A sample form for estimating the costs of storage system installation labor.

Heat-Delivery Loop Materials Costs

The costs for the heat-delivery loop are best estimated in two stages--materials, then labor. In many cases, the materials selected may affect the labor costs for installation.

A sample form for estimating the costs of heat-delivery loop materials is shown in Figure 20.7.

HEAT DELIVERY LOOP MATERIALS			
Materials, By Item	**Model**	**Cost Estimate**	**Job Price**
Filter, Heat Delivery Manifold	______	______	______
3-Way Valve, Heat Delivery Manifold	______	______	______
3-Way Valve, Heat Return Manifold	______	______	______
Solar Fan Coil	______	______	______
Heat Pump	______	______	______
Water Preheat Tank	______	______	______
Auxiliary Building Heater	______	______	______
Coil Chamber and Plenum	______	______	______
Blower, Solar Fan Coil	______	______	______
Expansion Tank	______	______	______
Pressure/Temperature Relief Valve	______	______	______
Pump, Water Preheater	______	______	______
Pump, Solar Fan Coil	______	______	______
Pump, Heat Pump	______	______	______
2-Manual 3-Way Valves	______	______	______
Check Valve	______	______	______
Differential Controller, Preheater Tank	______	______	______
Controller, Heat Delivery System	______	______	______
Cooling Tower (optional)	______	______	______
Heat Delivery Loop Piping	______	______	______
Tees	______	______	______
Elbows	______	______	______
45° Elbows	______	______	______
Miscellaneous Fittings	______	______	______
Insulation for Pipes and Components	______	______	______
		Total:	______

Figure 20.7 A sample form for estimating the costs of materials for the heat-delivery loop

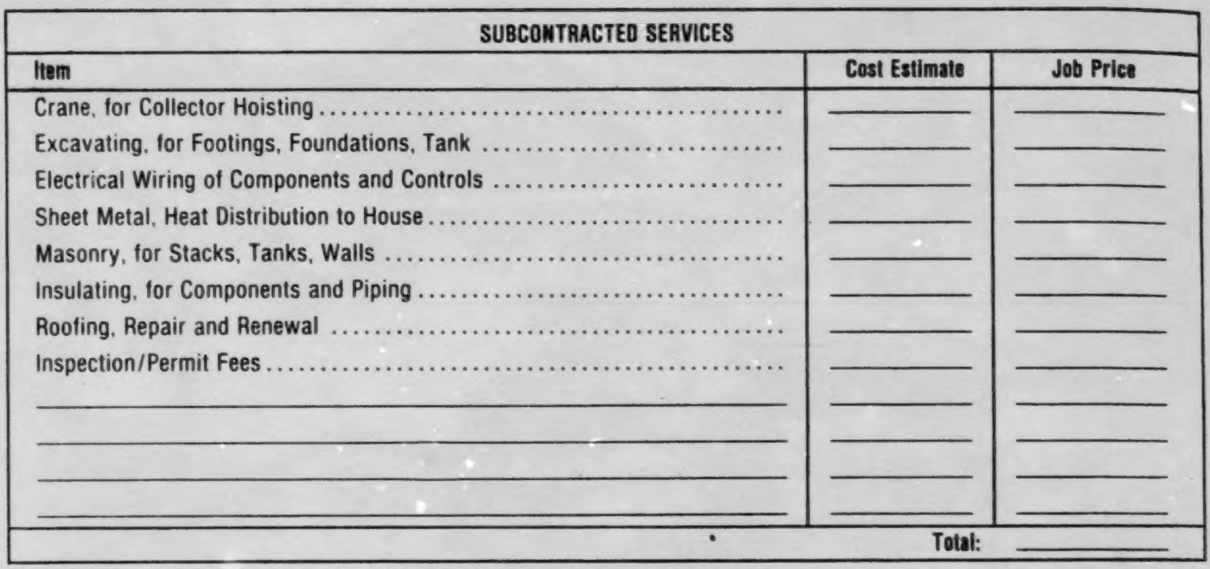
Heat-Delivery Loop Installation Labor Costs

A sample form for estimating the costs of heat-delivery loop installation labor is shown in Figure 20.8. This form includes insurance and benefit provisions which are actually indirect costs, but are included here for convenience. Items that should be included in insurance and taxes are: workman's compensation, FICA (employer's share), unemployment taxes (federal and State), union dues, and inspection fees. Items that should be included in the employee benefits package would normally include: health and life insurance, paid vacations, holiday and sickness allowances, bonus and pension plans, and any other employee benefits.

HEAT DELIVERY LOOP INSTALLATION				
Labor Items	**No. Men**	**Hours**	**Labor Rate**	**Total Cost**
Transport Components to Job Site				
Install Water Preheater				
Install Solar Coil Chamber				
Install Solar Fan Coil Blower				
Install Solar Fan Coil				
Install Heat Pump				
Install Ductwork to Cold Return				
Install Auxiliary Building Heater				
Install Expansion Tank				
Install Cooling Tower (optional)				
Pipe Delivery/Return Manifolds				
Pipe Water Preheater				
Pipe Solar Fan Coil				
Pipe Heat Pump				
Pipe Auxiliary Heater				
Pipe Cooling Tower (optional)				
Install Water Preheater Controller				
Install Heat Delivery Controller				
Inspect and Check Piping Loop Against Working Drawings & Specs				
			Subtotal:	
Fill System Loops				
Start-up and Check-out Loops				
Leak Repair Allowance				
Insulate Piping & Components				
Label & Identify Loop Parts				
Type Instruction/Service Manual				
Paint and Clean-up				
			Subtotal:	
Insurance and Taxes				
Employee Benefits				
			Subtotal:	
			Profit:	
			Total:	

Subcontracted Services

A sample form for estimating the costs of any subcontracted services is shown in figure 20.9. This form makes allowance for estimating and pricing machinery rental and work performed by other trades.



SUBCONTRACTED SERVICES

Item	Cost Estimate	Job Price
Crane, for Collector Hoisting	________	________
Excavating, for Footings, Foundations, Tank	________	________
Electrical Wiring of Components and Controls	________	________
Sheet Metal, Heat Distribution to House	________	________
Masonry, for Stacks, Tanks, Walls	________	________
Insulating, for Components and Piping	________	________
Roofing, Repair and Renewal	________	________
Inspection/Permit Fees	________	________
________	________	________
________	________	________
________	________	________
________	________	________
	Total:	________

Figure 20.9 A sample form for estimating the costs of subcontracted services.

Spaces are given in the form for estimated costs as well as the quoted prices. Job price minus estimated cost equals the gross estimated profit. By splitting out the estimated profit on each item, you can plan the proper markup for that service.

Education Costs

A sample form for estimating education costs is shown below. This form covers your costs for reference books, attendance at solar installer schools, travel and expenses for manufacturer technical services or consultation. These costs are part of your investment in becoming a knowledgable solar contractor. They should be recovered during the first year of work.

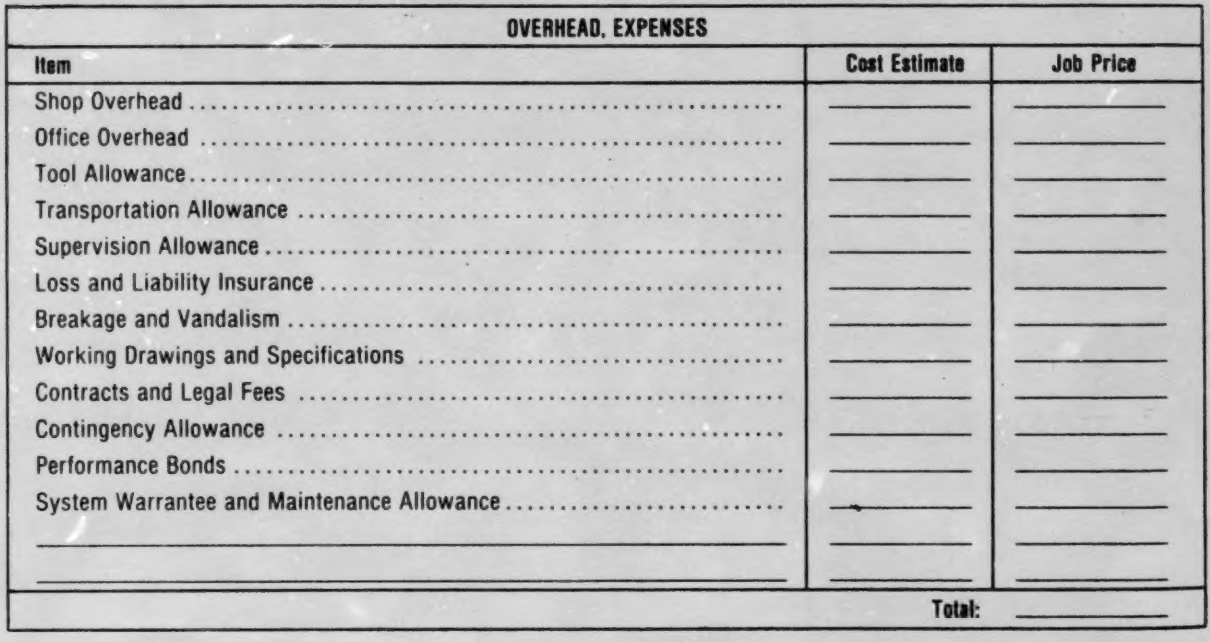
EDUCATION SERVICES

EDUCATION ITEMS	COST ESTIMATE	JOB PRICE
The Solar Decision Book	______	______
ASHRAE Handbook of Fundamentals.	______	______
ANSI A 58.1 (1972) Building Code Requirements for Minimum Design Loads	______	______
FHA: Intermediate Minimum Property Stds. Supplement, Solar Heating and Domestic Hot Water Systems	______	______
ARI Std 410: Forced Air Cooling and Air Heating Coils	______	______
NFPA 90A: (1976) Stds for the Installation of Air Conditioning and Ventilating Systems	______	______
NFPA 90B: Stds for the Installation of Warm Air Heating and Air Conditioning Systems.	______	______
Other: ______________________	______	______
______________________	______	______
Solar Installers School.	______	______
Manufacturers Technical Service.	______	______
Total:	______	______

Spaces are given for estimated costs as well as the quoted prices. Job price minus estimated cost equals the gross estimated profit. By splitting out the estimated profit on each item, you can plan the proper markup for that material or service.

Overhead And Miscellaneous Expenses

A sample form for estimating the costs of your overhead and miscellaneous expenses is shown in Figure 20.10. This is where you add your expense of being in business to the price quotation. Your office, your shop, your tools, your supervision should be included in the job price. So should such costs as those for vandalism, drawings, legal fees, performance bonds, warrantees, and maintenance contracts.



OVERHEAD. EXPENSES

Item	Cost Estimate	Job Price
Shop Overhead	______	______
Office Overhead	______	______
Tool Allowance	______	______
Transportation Allowance	______	______
Supervision Allowance	______	______
Loss and Liability Insurance	______	______
Breakage and Vandalism	______	______
Working Drawings and Specifications	______	______
Contracts and Legal Fees	______	______
Contingency Allowance	______	______
Performance Bonds	______	______
System Warrantee and Maintenance Allowance	______	______
______	______	______
______	______	______
	Total:	______

Figure 20.10 A sample form for estimating the costs of overhead and miscellaneous expenses.

Spaces are given for estimated costs as well as the quoted prices. Job price minus estimated cost equals the gross estimated profit. By splitting out the estimated profit on each item, you can plan the proper markup for that item of expense.

Job Pricing

Much of your success in business will depend on how well you price your goods or services. If your prices are so low that your margin does not cover expenses, or so high that you can't build up sales volume, you will fail to make profits.

In operating your business, you will have to decide upon the general price level you expect to maintain; that is, whether you expect to cater to people buying in the high, medium or low price range. This is tied up with your choice of location, quality of goods handled, and services to be offered.

After establishing the general price policy, you are ready to price individual items. To be certain that you do not underprice, you should know the percentage of gross margin to sales needed in the total of all items to cover expenses and profit. If you have been in business a year or longer, you can analyze your past records and find out the percentages for operating expenses and net profit. If you are just starting a business, you will have to estimate your sales and expenses carefully. Suppose you figure the margin you need to be 30 percent of sales. To obtain a 30 percent gross margin on an item, you must mark up its cost to you by 42.9 percent. This is because margin is a percentage of sales, while markup is a percentage of cost of merchandise.

However, in this example, you would not obtain 30 percent margin if each individual item were marked up only 42.9 percent. No allowance has been made for markdowns and shrinkage in this markup. Markdowns are reductions from the original selling prices. Among the reasons for them are overstocking as a result of unwise buying, sudden changes in style, unseasonable weather, soiled and faded goods used for displays, and broken lots. "Shrinkage" is the term used for losses due to theft, spoilage, and breakage. Allowances for markdowns and shrinkage must be added if you expect to maintain an average markup of 42.9 percent, or, to put it another way, a margin of 30 percent.

While the discussion of pricing may appear, in some respects, to be directed only to the pricing of merchandise in retail stores, it can be applied to other types of businesses as well. For services, the markup to cover selling and administrative costs should be placed over the direct cost of performing a particular service. If you are manufacturing a product, the costs of direct labor, materials and supplies for production, parts purchased from other concerns, special equipment (such as jigs, dies, fixtures, and other tools), plant overhead, selling and administrative expenses, must be carefully estimated. To compute a cost per unit will require an estimate of the number of units you plan to produce.

Not all items are marked up by the average mark-up. Some will take more, some less. For instance, increased sales resulting from a lower-than-average mark-up on a certain item may bring a higher gross profit. On the other hand, if the price is lowered too much, the resulting increase in sales will not raise the total gross profit enough to compensate for the low price. Above all, competitors' prices will govern your prices. You cannot sell a product if your competitor is greatly underselling you.

These and other reasons may cause you to vary your mark-up among items and services. There is no magic formula that will work on every product or every service all of the time. But you should keep in mind the over all average mark-up which you need to make a profit.

The Job Quotation

A realistic price is easy to calculate if a step-by-step method using forms similar to those introduced in preceeding discussions is employed. Simply, total the various prices on each of the forms compiled; you can use a sample form such as the following.

JOB PRICE

Engineering Services . . . . $__________

Building Modifications . . . . $__________

Collector Loop Materials . . . . $__________

Collector Loop Labor . . . . $__________

Storage Loop Materials . . . . $__________

Heat-Delivery Loop Materials . . . . . $__________

Heat-Delivery Loop Labor . . . . $__________

Subcontracted Services . . . . $__________

Education Costs . . . . $__________

Overhead and Miscellaneous . . . . . $__________

Total Job Quotation: $__________

This method uses just a few easy steps to a price you can live with; one that covers obvious costs as well as not-so-obvious costs. And one that will insure value for the owner's investment and a fair return for the contractor's materials and labor.

This is not the only method that can be used. A variety of contractor quotation programs exist; none of them are perfect and never will be as long as labor, weather, and dozens of suppliers are involved.

The decision to bid the job belongs to you, the contractor. If you do, this pricing method will help you to determine a fair price for both you and the customer.

Solar Appraisals By Engineering Firms

Is solar a good investment for the consumer? The question is simple, the answer is complex.

There are times when a solar system is not a smart purchase, when conventional systems are a better buy. Analysis may find that initial costs are prohibitive, or that the time period to pay back the investment is too long for the consumers needs. Or that some of the unknowns about solar, such as solar rights and property appreciation or depreciation, are too risky.

An examination of several examples of solar appraisals by an engineering firm (given in subsequent sections) will show that this firm recommended solar systems in some instances, while vetoing it in other cases. The appraisals are normally conducted for a small fee which should be reasonable and for it the buyer is assured of quality evaluations--specific advice on how to save on energy costs. Risks were reduced to a minimum, and the buyer may have saved himself thousands of dollars by taking the engineer's advice.

Solar Appraisal By An Independent Engineer -- Case I

May 30, 1975

Dear

The evaluation of your home's solar heating and energy conservation potential is complete and a synopsis of the results is given below. A detailed analysis is enclosed in the work sheets attached to this letter. In our analysis, the projected cost of electrical energy was used to determine how much solar energy and improved insulation would save you over a fifteen-year period. This cost savings was used to select an optimum system for you. However, projecting energy costs is risky because the effects of oil embargoes or of the President placing taxes on oil cannot be accurately determined. The projection data that we use was taken from a government report and probably underestimates future energy costs. Therefore, (company) expects you to save more than the amount we have stated in this evaluation.

The following is a synopsis of the evaluation results:

1. Your present home requires 38,500 Btu/degree day* for home heating and domestic hot water. This presently costs you $1200 per year. In fifteen years, based on projected energy costs, you would spend $2200 per year for the same. Accumulating all the yearly costs ofer a fifteen-year period, you would spend $26,257 to heat your home and hot water.

2. Your home insulation can be improved which will lower your annual heating bill. (Company) recommends the addition of storm windows and doors, insulating the hot air ducts and adding an additional three inches of insulation in the ceiling. Although you presently have thermopane windows and doors, storm doors and windows would reduce infiltration losses. These insulation improvements would lower your heating load by 21% and save you $251 per year at present energy costs. Using projected energy costs, over the course of fifteen years, these insulation improvements would save you $5492.08.

3. An operational schematic of the solar heating system is attached. It uses water as the heat transfer media and will provide domestic hot water as well as home heat. In the summer, excess solar heat not needed to heat the domestic water could be used to heat the swimming pool.

4. Two solar heating system sizes were optimal. The solar heating system (company) recommends would have a solar collector area of 500 square feet, and would be mounted on modules in your backyard. Since your home faces 41 degrees away from south, solar collector placement on your roof was unadvisable. A diagram of this system, shown with the proposed swimming pool, is also attached. (Company) recommends this solar heating system be considered only in conjunction with the improved insulation package.

---

*A degree-day is an engineering measure of the amount of heat your home requires based on local weather data. A Btu is a unit of heat.

5. The other solar heating system optimized has an area of 800 square feet. However, since a larger system is more costly, and the recommended system is mounted on modules, additional collector area could be added to the recommended system at a later date.

6. The recommended 500 square feet system would supply 35% of the yearly heating load of the recommended better insulated home. This system (recommended system No. 3 of the work sheets) would, in combination with the insulation package, save you $608 per year, or over half of what you are presently paying. Usine projected energy costs, this solar heat and insulation package would save you $13,288 over the course of fifteen years.

7. The solar heating system is estimated to cost $20 per square foot yielding a cost of $10,000. The insulation improvements are estimated to cost $2,000. The total package cost is estimated to be $12,000, and should pay for itself in about thirteen years. A firm fixed price for the package would be quoted when a solar heating installation contract is negotiated. If you install the system yourself, (company) supplying plans, technical advice and materials, the solar heating system cost could be reduced to $6,500.

8. The excess solar heat obtained in the summer months can be used to heat your pool at a savings of $290 per summer at present energy costs. Using projected energy costs, over the course of fifteen years, the excess solar heat would save you an additional $6,300. This excess solar heat, in combination with a pool cover, which (company) recommends, would raise the pool water temperature 7 degrees over that of an unheated, uncovered pool.

The following table lists our recommendations, their costs, and your expected savings.

RECOMMENDATION	ESTIMATED COST	PROJECTED SAVINGS OVER FIFTEEN YEARS
Insulation Package	$ 2,000	$ 5,492
500-square-foot solar heating	10,000	13,288 (includes insulation)
Solar pool heat	–0–	6,300
Total	12,000	19,588

If you have any questions about this evaluation, please feel free to contact us.

Sincerely,

Enclosures:
(1) Work Sheets
(2) Operational Schematic
(3) Collector Array Diagram
(4) Solar Profile

Solar Heating Potential Survey

DATE: May 30, 1975
NAME:
ADDRESS:

SURVEYORS (S):

SURVEY INFORMATION ATTACHED: yes

PRESENT HEATING LOADS AND REQUIREMENTS

DOMESTIC HOT WATER	LOAD	PRESENT ESTIMATED COST
MINIMUM	440 kWh/mo	$15.00/mo
MAXIMUM	880 kWh/mo	30.00/mo

PRESENT HOME HEATING REQUIREMENTS:

HEATING BILLS: Analysis of your home heating bills in conjunction with local weather data yields a home heating load of 38,500 Btu/degree-day.

CONSTRUCTION DETAILS (Drawings available):

ITEM	AREA (ft²)	NOTES
CEILING	2,718	6" insulation
CEILING (other)	0	
WALLS (exposed to dirt)	200	block
WALLS (exposed to air)	1,936	3.62" insulation
WALLS (to unheated space)	0	
WALLS (other)	435	block to air
WINDOWS AND S.G. DOORS	400	thermopane
WINDOWS (other)	13	skylight
FLOOR (crawl space)	560	6" insulation
FLOOR (unheated space)	644	
FLOOR (dirt)	2,592	
FLOOR (other)	0	
ADDITIONAL	0	

Analysis of your home construction details yields a home heating load of 39,950 Btu/degree-day.

HOME HEATING LOAD USED IN THIS EVALUATION: 38,500 Btu/degree-day

ESTIMATED YEARLY HEATING LOAD, INCLUDING HOME HEAT AND DOMESTIC HOT WATER

Btu/year	kWh/year	Present Cost
211×10^6	61.8×10^3	$1,200.00

PRESENT COST OF HEATING ENERGY: $0.02/kWh

INSULATION EVALUATION

WINDOWS: Add storm windows to reduce infiltration losses

SAVINGS: Reduce heat load by 6 percent

COST:

DOORS: Add storm doors to reduce infiltration losses

SAVINGS: Reduce heat losses by 7 percent

COST:

FLOORS: None

SAVINGS:

COST:

CEILING: Increase insulation thickness from 6 inches to 9 inches

SAVINGS: Reduce heat load by 2 percent

COST:

WALLS: None

SAVINGS:

COST:

OTHER: Insulate exposed air ducts with 3.5 inches insulation

SAVINGS: 10 percent

COST:

INSULATION IMPROVEMENT EFFECT ON PRESENT YEARLY HEATING LOAD

PRESENT HEAT LOAD	IMPROVED HEAT LOAD	IMPROVED HEATING COST	YEARLY SAVINGS USING PRESENT ENERGY COSTS
61,800 kWh/yr	47,400 kWh/yr	$949.00/yr	$251.00/yr

TOTAL COST OF INSULATION IMPROVEMENT RECOMMENDATIONS:

SOLAR HEATING SYSTEM APPLIED TO YOUR HOME

LOCATION OF THE SOLAR COLLECTOR ARRAY:	The best and easiest to install location for the solar collectors would be in the backyard. A diagram of this array, shown together with the proposed swimming pool is included in this evaluation.
LOCATION OF THE STORAGE TANK:	The heat storage tank would best be located inside the structure which holds the solar collector array.
OTHER CONSIDERATIONS:	This evaluation will also consider the solar heating impact on a proposed swimming pool.

Solar Heating System

RECOMMENDED SYSTEM #1

COLLECTOR AREA: 800 square feet LOCATION: Backyard
ORIENTATION: See diagram TILT ANGLE: 55 degrees
STORAGE TANK SIZE: 1200 gallons
STORAGE TANK LOCATION: Backyard

System Performance Details

MONTH	PRESENT HOME HEAT LOAD/MO (Million Btu)	HEAT SUPPLIED BY RECOMMENDED SOLAR HEATING SYSTEM (Million Btu/mo)	PERCENT SOLAR HEAT	EXCESS HEAT (FOR POOL) (Million Btu/mo)
JAN	40.8	8.2	20	-
FEB	35.0	9.0	25.7	-
MAR	29.2	11.5	39.3	-
APR	15.2	12.3	80.9	-
MAY	6.6	6.6	100	7.7
JUN	1.7	1.7	100	13.6
JUL	1.6	1.6	100	15.1
AUG	1.6	1.6	100	16.3
SEP	3.2	3.2	100	13.0
OCT	12.8	12.8	100	2.8
NOV	24 9	10.6	42.5	-
DEC	38.5	7.7	20	-
TOTAL	211.1	86.8		

PRESENT YEARLY HEATING BILL SAVINGS FOR ABOVE SYSTEM USING PRESENT ENERGY COSTS: $488.00

PROJECTED YEARLY HEATING COSTS WITH AND WITHOUT SOLAR HEAT

TIME	PRESENT HOME HEATING COSTS NO SOLAR HEAT $/YR	PRESENT HOME HEATING COSTS W/SOLAR HEAT $/YR	PROJECTED YEARLY SAVINGS
PRESENT	1,200	712	488
IN 5 YEARS	1,532	910	622
IN 10 YEARS	1,866	1,108	758
IN 15 YEARS	2,198	1,305	893
ACCUMULATED COSTS AND SAVINGS	26,257	15,596	10,668

ESTIMATED* COST OF INSTALLING SOLAR HEATING SYSTEM: $20.00/ft² = $16,000.00

NOTE: This system would take about 20 years to pay for itself.

* The cost of solar heating system is only an estimate used in this evaluation. Although the estimate should not change by much a firm fixed price would be quoted when a solar heating installation contract is negotiated.

RECOMMENDED SYSTEM #2

COLLECTOR AREA: 800 square feet   LOCATION: Backyard

ORIENTATION; see diagram   TILT ANGLE: 55 degrees

STORAGE TANK SIZE: 1200 gallons

STORAGE TANK LOCATION: Backyard

OTHER CONSIDERATIONS: Assume home to be insulated to above recommendations. Home heating load reduced to 47,400 kWh/yr.

PERCENT OF YEARLY HEATING BILL SUPPLIED BY ABOVE SOLAR HEATING SYSTEM: 52.7 percent for insulated home above, based on 47,400 kWh/yr usage.

PROJECTED YEARLY HEATING COSTS FOR UPGRADED INSULATION HOME WITH AN 800-SQUARE FOOT SOLAR HEATING SYSTEM

Time	Present home, present insulation no solar $/yr	Insulated home with solar heat $/yr	Projected yearly savings $/yr
Present	1,200	448	752
In 5 years	1,532	549	983
In 10 years	1,866	696	1,170
In 15 years	2,198	820	1,378
Accumulated costs and savings in 15 years	26,257	9,516	16,731

ESTIMATED* COST OF INSTALLING SOLAR HEATING SYSTEM: $20/ft² plus $2,000 for insulation = $18,000

NOTE: This system would pay for itself in about 16 years.

*The cost of solar heating system is only an estimate used in this evaluation. Although the estimate should not change by much, a firm fixed price would be quoted when a solar heating installation contract is negotiated.

RECOMMENDED SYSTEM #3

COLLECTOR AREA: 500 square feet LOCATION: Backyard

ORIENTATION: See diagram TILT ANGLE: 55 degrees

STORAGE TANK SIZE: 750 gallons

STORAGE TANK LOCATION: Backyard

OTHER CONSIDERATIONS: Consider home to be insulated to recommendations. Home heating load estimated to be reduced to 47,400 kWh/yr.

PERCENT OF YEARLY HEATING BILL SUPPLIED BY ABOVE SOLAR HEATING SYSTEM: 35.6% of insulated home above, based on 47,400 kWh/yr usage.

PROJECTED YEARLY HEATING COSTS FOR UPGRADED INSULATION HOME WITH A 500 SQUARE FOOT SOLAR HEATING SYSTEM

Time	Present home present insulation, no solar $/yr	Insulated home with solar heat $/yr	Projected yearly savings $/yr
Present	1,200	610	590
In 5 years	1,532	748	784
In 10 years	1,866	949	917
In 15 years	2,198	1,117	1,081
Accumulated costs and savings	26,257	12,968	13,288

ESTIMATED* COSTS OF INSTALLING SOLAR HEATING SYSTEM: $20/ft^2 plus $2,000 for Insulation improvements = $12,000

NOTE: This system would pay for itself in about 13 years.

*The cost of solar heating system is only an estimate used in this evaluation. Although the estimate should not change by much, a firm fixed price would be quoted when a solar heating installation contract is negotiated.

SOLAR HEATING SYSTEM FOR POOL

POOL SIZE: 40 ft by 20 ft by 5 ft (average)

POOL LOCATION: Backyard, between house and collector array

SOLAR COLLECTOR SIZE: 500 square feet

NOTES: Collector used for home heat. Excess in the summer time will be used to help heat pool. Heat input from standard pool heater was not considered.

POOL COVERING: A pool cover was considered. It would be in place 12 hours per day.

WATER TEMPERATURES IN POOL, DEGREES FAHRENHEIT

Month	No pool cover, no solar heat	No pool cover, solar heat	Pool cover solar heat	Pool cover no solar heat	Average air temp
May	63	64	68	67	66
Jun	70	72	77	74	74
Jul	73	75	81	77	79
Aug	70	73	78	74	77
Sep	64	66	71	67	70

TOTAL AMOUNT OF ENERGY SUPPLIED TO POOL DURING SUMMER MONTHS: 49.6 million Btu

TOTAL AMOUNT OF ENERGY SUPPLIED TO POOL DURING WINTER MONTHS: 0

ESTIMATED ENERGY COSTS FOR CONVENTIONAL POOL HEATER: $0.020/kWh summer
0.0 winter

ESTIMATED ENERGY SAVINGS PER YEAR USING SOLAR HEAT FOR POOL: $290.00

COMMENTS: Solar augmented pool heat with a pool cover used 12 hours per day would raise the pool water temperature by about 7 degrees as compared to an unheated, uncovered pool.

Solar Appraisal By An Independent Engineer -- Case II

July 17, 1975

Dear

An evaluation of the energy required for the home you plan to build is complete and a synopsis of the results is given below. A detailed analysis is enclosed in the work sheet attached. In our analysis, the projected cost of energy was used to determine how much solar energy and various wall construction would save you. However, projecting energy cost is risky because the effect of oil embargoes, taxes, and energy legislation cannot be accurately determined. The projection data that we used was taken from a government report and probably underestimates future energy costs. Therefore, [company] expects you to save more than the amount stated in this evaluation.

Sincerely

President,

Enclosures

SYNOPSIS OF EVALUATION RESULTS

The following is a synopsis of the evaluation results:

1. The calculated heating requirement of your home is 115.8 million Btu's per year using the heat loss data presented in the attached worksheet.

2. The walls were assumed to be ½-inch dry wall on 2-inch by 4-inch studs, with 3½" fiberglass insulation, with ½" plywood exterior sheathing finished with ¾-inch cedar boards with batting strips. We recommend that you do not have an air space under the ¾-inch cedar as this will save only .2 Btu/Ft²/Degree Day and will have to spend a large amount of time and money assuring that there is no infiltration losses. If you nail the ¾-inch cedar directly to the ½-inch sheathing and then nail on the batting strips, you will have a much stronger construction and minimize the effect of infiltration.

3. We have calculated the heat loss of the windows, doors, walls and ceilings for various types of construction. Considering the estimated cost of these various wall constructions, we recommend that you consider a wall constructed of 2- by 4-inch studs with ½-inch Polyurethane Foam (PF) and 3-inch Urea Foam (UF) sprayed on before the interior of your studs are closed up. This type of construction offers very effective thermal and acoustic insulation. The PF forms a vapor barrier and cuts infiltration losses. The UF is cheaper and protects the PF from fire.

4. The conduction and infiltration losses of the sliding glass doors is substantial, comprising 26 percent of your heat load. We recommend that you take a careful look at these losses. Our calculations were based on installation that was made using caulking, weather stripping and good construction techniques. If you do not make sure that these doors are of high quality and are installed properly, you can expect to realize infiltration losses as large as two times those calculated

5. Shading is another important factor to consider. We estimate that the output from a solar heating system will be degrated 25 percent if you clear all trees, taller than your house, on the east, south, and west side of your house that are closer than 50 feet. If you clear these same trees that are within 95 feet, you will realize little shading effect. If you do not clear any trees, we would not recommend solar heat for your home.

6. The enclosed system performance data sheet compares five systems from 100 to 500 ft^2. The 100, 150, and 200 ft^2 systems provide heat only for domestic hot water. Systems of 300 ft^2 and larger provide heat for both domestic hot water and home heat. Interpretation of this data yields the following conclusions.

a. Solar home heat is not economically advantageous for your home as compared to oil heat. This is attributable to a combination of your shallow roof, the present relatively low cost of oil heat, and the present high cost of a solar collector.

b. A domestic solar hot water heater system could provide 55 to 79 percent of your hot water need and pay for itself in 10 years.

Present Heating Loads and Costs

Domestic hot water (electrically heated)	Load	**Present estimated cost**
2 persons	3662 kWh/yr	$148/yr*
4 persons	7325 kWh/yr	$297/yr*

*Based on cost of $.0405/kWh

Analysis of your home construction details yields a home heating load of:

23,139 Btu/degree day

This heat load, in conjunction with local weather, yields a home heating requirement of:

115.98 x 10^6 Btu/yr

Home heating	Load	Presented estimated cost
Electric: @ $.0405/kWh	43,862 kWh/yr	$1,776/yr
Oil: @ $.40/gal	115.98 x 10^6 Btu/yr	$332/yr

Type construction	Heat loss Btu/ft²/deg day	Approximate cost $/ft²
Glass, Single	13.0	--
Glass, Double ¼" Space	9.1	--
Glass, Single + Storm Windows	9.9	--
Frame, 2" × 4" with 3½" Fiberglass	1.8	.4*
Frame, 2" × 4" with 3½" Fiberglass + 1" Air	1.7	--
Frame, 2" × 4" with ½" PF + 3" UF	1.3	.8**
Frame, 2" × 4" with ½" PF + 3" UF + 1" Air	1.05	--
Frame, 2" × 6" with 5½" Fiberglass	1.13	.55*
Frame, 2" × 6" with ½" PF + 5" UF	.76	1.0**
Block, 8"	6.5	--
Block, 8" 1" Air + Interior	4.0	--
Block, 8" ¾" Styrofoam + Interior	3.6	--
Block, 8" 3½" Fiberglass	1.2	--
Block, 8" ½" PF + 3" UF	.92	--
Roofing, Shingles only	----	.4 (installed)
Roofing, 2" wood, 2½" PF + Shingles	1.14	1.95**
Roofing, 2½" PF only	----	1.00

*Cost of frame materials (interior and exterior materials not included).

**Same as above with insulation installed.

House Heating Load

Components	Area ft²	Pct of total area	Loss factor Btu/ft²/deg day	Loss Btu/deg day	Pct of total loss
Windows, Fixed	383	6.0	9.1	3,485	16.1
Windows, Sliding	45	.7	9.1	410	1.8
Infiltration windows	428	6.7	---	525	2.3
Doors, Swinging	28	.4	9.1	255	1.1
Infiltration doors, Swinging	28	.4	---	367	1.6
Doors, Sliding	306	4.8	9.1	2,785	12.0
Infiltration doors, Sliding	306	4.8	---	3,244	14.0
Ceiling	1,784	28.3	1.14	2,034	8.8
Wall 8" block	317	5.0	6.5	2,061	8.9
Wall to garage	272	4.3	4.36	1,186	5.1
Wall to fill	592	9.4	2.35	1,390	6.0
Wall frame	922	14.6	1.8	1,660	7.2
Floor to fill	1,389	22.0	2.34	3,250	14.0
Floor to garage	264	4.2	1.89	500	2.2

Projected Heating Costs

TIME	ELECTRIC - HOT WATER OIL - HOME HEATING		TOTAL ELECTRIC	
	Rate increase of 5.55 pct/yr	7 pct/yr	5.55 pct/yr	7 pct/yr
	TOTAL COST			
Present	$ 630/yr	$ 630/yr	$2,073/yr	$2,073/yr
In 5 yrs	806.4/yr	850.5/yr	2,080/yr	2,199/yr
In 10 yrs	1,008/yr	1,071/yr	2,533/yr	2,769/yr
In 15 yrs	1,160/yr	1,292/yr	2,984/yr	3,280/yr
	ACCUMULATED COSTS			
In 5 yrs	3,567/yr	3,701/yr	9,273/yr	9,568/yr
In 10 yrs	8,063/yr	8,506/yr	20,805/yr	21,986/yr
In 15 yrs	13,292/yr	14,412/yr	34,590/yr	37,253/yr

Monthly Heating Requirements and Available Solar Energy

Month and no. degree days	Home heat load/mo (million Btu)	Hot water load/mo (million Btu)	Total load/mo (million Btu)	Available solar energy/mo Btu/ft^2
Jan. 1,020	23.60	2.07	25.67	6,448
Feb. 874	20.25	2.07	22.32	7,812
Mar. 719	16.64	2.07	18.71	11,191
Apr. 357	8.27	2.07	10.34	12,480
May 131	3.03	2.07	5.10	14,446
Jun. 5	.12	2.07	2.19	15,150
Jul. 0	---	2.07	2.07	15,779
Aug. 0	---	2.07	2.07	14,973
Sep. 43	1.00	2.07	3.07	12,990
Oct. 291	7.72	2.07	9.80	11,222
Nov. 609	14.10	2.07	16.17	7,950
Dec. 961	22.24	2.07	24.31	6,293

Solar Domestic Hot Water Heating System

Recommended system

Collector area: 100
Orientation: S 15° W
Storage tank size: 250
Storage tank location: Basement

Location: Roof
Tilt angle: 18°

System Performance Details

Month	Hot water heating load/mo (million Btu)	Heat supplied by recommended solar system (million Btu/mo)	Percent solar heat
Jan.	2.07	.65	31
Feb.	2.07	.78	38
Mar.	2.07	1.12	54
Apr.	2.07	1.25	60
May	2.07	1.44	70
Jun.	2.07	1.52	73
Jul.	2.07	1.58	76
Aug.	2.07	1.50	72
Sep.	2.07	1.30	63
Oct.	2.07	1.12	54
Nov.	2.07	.8	39
Dec.	2.07	.63	30
Total	24.84	13.69	

Present yearly heating bill savings for above system using present energy costs: $163

Projected Yearly Heating Costs with and Without Solar Heat

Time	Present heating costs no solar heat $/yr	Present heating costs w/solar heat $/yr	Accumulated savings
Present	297	134	163
In 5 yrs	380	171	928
In 10 yrs	475	214	2,082
In 15 yrs	547	246	3,462

Estimated* cost of installing solar heating system: @ $20/ft² = $2,000

* The cost of solar heating system is only an estimate used in this evaluation. Although the estimate should not change by much, a firm fixed price would be quoted when a solar heating installation contract is negotiated.

NOTE: This system would take about 10 years to pay for itself.

System Performance Data

System size ft^2	Energy provided (million Btu/pct	Present cost $.04/kWh	Savings first yr	Estimated accumulated savings @ 5.55 pct			Est. system cost	Years for savings to pay for system
				In 5 yrs	In 10 yrs	In 15 yrs		
100								
Hot water	13.7	$297	160	$912	$2,045	$3,398	$2,000	10
Heat	--							
Total	13.7							
	55%							
150								
Hot water	19.74	297	231	1,317	2,952	4,906	3,000	10
Heat	---							
Total	19.74							
	79%							
200								
Hot water	22.26	297	261	1,487	3,341	5,544	4,000	12
Heat	---							
Total	22.26							
	89%							
300								
Hot water	24.60	297	297	1,603	3,745	6,223	6,000	14
Heat	7.63	303	19.6	112	251	417		
Total	32.63	600	312.6	1,715	3,996	6,640		
	25%							
500								
Hot water	25.0	297	297	1,693	3,796	6,308	10,000	20
Heat	20.81	303	54	307	690	1,147		
Total	45.81	600	347	1,910	4,486	7,455		
	35%							

Solar Appraisal By An Independent Engineer -- Case III

Silver Spring, MD 20904

Dear Mr. A

The evaluation of your home's solar heating and energy conservation potential is complete and a synopsis of the results is given below. Detailed analyses are enclosed in the work sheets attached to this letter. [Company] has also included the effect of a heat pump on your yearly heating costs in addition to our normal analysis of a solar heating system for your home. In all of our analyses the projected cost of electrical energy was used to determine how much solar energy heating systems (or heat pump systems) would save you over a fifteen year period. This cost savings was used in selecting an optimum system for you. However, projecting energy costs is risky because the effects of oil embargoes or Presidential taxes cannot be accurately determined. The projection data that we used was taken from government reports and probably underestimates future energy costs. [Company] expects you to save more than the amount we have stated in this evaluation. Throughout this report, we have used an energy cost inflation rate of 7%.

Heating system capital recovery costs were not included in this evaluation. Since loan interest rates and periods vary, an accurate determination of investment money cost cannot be made. However, it is important to note that money costs will affect the systems payback period (the period of time after which the system operates for essentially free). There is sufficient data within this evaluation to allow you to determine the effect of money costs for your own situation.

The following is a synopsis of the evaluation results:

1. HEATING REQUIREMENTS—
   Your home requires 22.636 kwhr/yr for space heating and 5,110 kwhr/yr for domestic hot water heating. During the present year, these two items will cost you $903. In fifteen years, based on projected energy costs, you will spend $2,327 for the same energy. Accumulating all the yearly costs over a fifteen year period, you would spend $26,257 to heat your home and hot water.
2. INSULATION EVALUATION—
   The insulation in your home is outstanding. However, if you should ever finish and heat your basement, [company] recommends the basement block wall be insulated. One type of insulation material could be ¾-inch thick styrofoam boards that fit behind paneling. Since your basement is presently unheated and unfinished, the minor effect of basement insulation on your present heating requirements was not included in this evaluation.
3. ENERGY CONSERVATION IMPROVEMENTS (HEAT PUMP)—
   The effect of an electric heat pump on your yearly heating bill was considered. A heat pump can reduce your space heating requirements (not hot water requirements) by approximately 30% in the Washington, D.C. area. This would reduce the yearly total heating bill from $903 to $685 per year for a yearly savings of $218. Using projected energy costs, a heat pump would save your $5,475 over the course of fifteen years. An installed heat pump is estimated to cost $2,500 and would require 8¾ years to pay back its initial cost. We obtained unfavorable impressions about heat pumps from two local refrigeration/air-conditioning contractors. Their two main complaints were low reliability and high maintenance. However, it is possible that recent heat pump improvements have dimished these problems.

   Hybrid heat pumpm/solar collector systems have also been proposed, and promise excellent efficiency. However, data on this system's performance is unavailable, and [company] did not estimate its effect on your heating bill. We do not recommend the hybrid system at this time.
4. SOLAR HEATING SYSTEMS—
   Two solar heating systems were optimized for your home. One would heat both your home and domestic hot water and the other would heat only your domestic hot water. Both systems would use a solar collector mounted on your south facing roof and store energy in a heat storage tank located in your basement.

A. SOLAR SPACE HEATING SYSTEM — For solar heating of your home and domestic hot water, [company] recommends a solar heating system with a collector area of 400 square feet and a storage tank size of 800 gallons. This system would supply 45% of the yearly heating energy needs for your home. It would reduce your present heating energy costs from $903 to $496 and save you $407 per year. Based on projected energy costs, this system would save you $10,224 over the course of fifteen years. This system is estimated to cost $8,000 and would require 12¾ years to pay for itself.

B. SOLAR DOMESTIC HOT WATER HEATING SYSTEM — The second solar heating system considered for your home would heat only your domestic hot water. For this system, [company] recommends a solar collector with an area of 100 square feet and a storage tank size of 150 gallons. This system would supply 85% of your estimated domestic hot water needs. Your average hot water requirements were estimated to be 100 gallons per day. Since you presently spend approximately $177 per year to heat domestic hot water, this system would presently save you $150 per year. In fifteen years, this system would save you $389 per year. Using projected energy costs, this system would save you $3,793 over the course of fifteen years. A solar heated domestic hot water system is estimated to cost $2,000 and would require 9¾ years to pay for itself. This system would be designed so that it could be expanded into System "A" at a future date if desired.

5. SOLAR HEATED POOL DATA—
Excess solar heat obtained in the summer months from the solar space heating system (400 square feet of collector area) could be used to heat your pool. This excess solar heat, in combination with a pool cover, which [company] recommends for higher pool temperatures, would raise the pool water temperature 6 degrees over that of an unheated, uncovered pool. This would presently save you $223 per year at present energy costs. Over the course of fifteen years, this solar pool heater would save you $5,600.

Both a heat pump and a solar heated domestic hot water system could be added to your home. These are separate systems, not the hybrid systems mentioned in 3 above. In combination, these two systems would presently save you $368 per year. Over a fifteen year period, using projected energy costs, they would save you a total of $9,268.

In summary, [company] recommends a preliminary installation of a solar heated domestic hot water system. It is less expensive than the solar space heating system and could easily be expanded into a space heating system if desired. It would be less expensive to expand an existing solar domestic hot water heating system than to initially install a solar space heating system. Part of the domestic hot water system, plumbing, controls, etc., also needed for the space heating system would already exist. The relatively inexpensive solar heated domestic hot water system would give you complete exposure to the potential of solar energy and would allow you the flexibility of installing a heat pump without wasted capital.

Solar Heating Potential Survey

DATE: 8 July 1975

NAME:
ADDRESS:

SURVEYOR(S):
SURVEY INFORMATION ATTACHED: No

PRESENT HEATING LOADS AND REQUIREMENTS

DOMESTIC HOT WATER:	LOAD	PRESENT ESTIMATED COST
MIN	366 kWh/mo	$149/yr
MAX	502 kWh/mo	$205/yr
	Avg = 434 kWh/mo	Avg = $177/yr

PRESENT HOME HEATING REQUIREMENTS:

HEATING BILLS: Analysis of your home heating bills in conjunction with local weather data yields a home heating load of:
Space heating = 22,636 kWh/yr
Domestic Hot Water = 5,110 kWh/yr

CONSTRUCTION DETAILS

ITEM	AREA (ft²)	NOTES
CEILING		
CEILING (OTHER)		
WALLS (EXPOSED TO DIRT)		
WALLS (EXPOSED TO AIR)		
WALLS (TO UNHEATED SPACE)		
WALLS (OTHER)		
WINDOWS AND S. G. Doors	*Not applicable*	
WINDOWS (OTHER)		
FLOOR (CRAWL SPACE)		
FLOOR (UNHEATED SPACE)		
FLOOR (DIRT)		
FLOOR (OTHER)		
ADDITIONAL		

Analysis of your home construction details yields a home heating load of:

Not applicable

HOME HEATING LOAD USED IN THIS EVALUATION: 22,636 kWh/yr

ESTIMATED YEARLY HEATING LOAD, INCLUDING HOME HEAT AND DOMESTIC HOT WATER

Btu/yr	kWh/yr	PRESENT COST
94.7×10^6	27,746	$903

PRESENT COST OF HEATING ENERGY: $0.0325/kWh

INSULATION EVALUATION

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WINDOWS:	Not Applicable	CEILING:	Not Applicable
DOORS:	Not Applicable	WALLS:	Not Applicable
FLOORS:	Not Applicable	OTHER:	Not Applicable

INSULATION IMPROVEMENT EFFECT ON PRESENT YEARLY HEATING LOAD

PRESENT HEAT LOAD	IMPROVED HEAT LOAD	IMPROVED HEATING COST	YEARLY SAVINGS USING PRESENT ENERGY COSTS
22,636 kWh/yr	N/A	N/A	N/A

TOTAL COST OF INSULATION IMPROVEMENT RECOMMENDATIONS: N/A

SOLAR HEATING SYSTEM APPLIED TO YOUR HOME

LOCATION OF THE SOLAR COLLECTOR ARRAY:

The best collector location would be on the south facing part of your roof. Although the shallow pitch of your roof degrades system performance slightly, it is less expensive to install more collector area than to change collector tilt angle.

LOCATION OF THE STORAGE TANK:

Basement of home.

OTHER CONSIDERATIONS:

Consider the impact of solar heating on the swimming pool water temperatures.

RECOMMENDED SYSTEM: Electric Heat Pump
COLLECTOR AREA: N/A
ORIENTATION: N/A
STORAGE TANK SIZE: N/A
STORAGE TANK LOCATION: N/A
OTHER CONSIDERATIONS: N/A
LOCATION: N/A
TILT ANGLE: N/A

PERCENT OF YEARLY HEATING BILL SUPPLIED BY ABOVE HEAT PUMP SYSTEM:
30 percent

Projected Yearly Heating Costs for Heat Pump Heating System

Time	Present home present insulation no solar $/yr	Insulated home with heat pump $/yr	Projected yearly savings $/yr
Present	903	685	218
In 5 yrs	1,182	897	285
In 10 yrs	1,659	1,259	400
In 15 yrs	2,327	1,765	562
Accumulated costs and savings in 15 yrs	22,683	17,207	5,476

ESTIMATED* COST OF INSTALLING ELECTRIC HEAT PUMP SYSTEM: $2500

NOTE: This system would pay for itself in about 8.75 years.

* The cost of solar heating system is only an estimate used in this evaluation. Although the estimate should not change by much, a firm fixed price would be quoted when a solar heating installation contract is negotiated

Solar Heating System

RECOMMENDED SYSTEM

COLLECTOR AREA: 400 Square feet
ORIENTATION: Due South
STORAGE TANK SIZE: 800 gallons
STORAGE TANK LOCATION: Basement

OTHER CONSIDERATIONS: Excess solar heat to swimming pool
LOCATION: Roof
TILT ANGLE: 26°

System Performance Details

Month	Present home heat load/mo (million Btu)	Heat supplied by recommended solar heating system (million Btu/mo)	Percent solar heat	Excess heat (for pool) (million Btu/mo)
Jan.	17.2	3.4	20	---
Feb.	14.8	4.1	28	---
Mar.	12.6	5.7	45	---
Apr.	6.9	6.2	90	0
May	4.6	4.6	100	2.6
Jun.	1.5	1.5	100	5.7
Jul.	1.5	1.5	100	5.9
Aug.	1.5	1.5	100	5.6
Sep.	2.1	2.1	100	4.3
Oct.	4.9	4.9	100	.7
Nov.	10.8	4.1	38	0
Dec.	16.3	3.1	20	---
Total	94.7	42.7	45%	24.8

PRESENT YEARLY HEATING BILL SAVINGS FOR ABOVE SYSTEM USING PRESENT ENERGY COSTS: $903/yr

Projected Yearly Heating Costs With and Without Solar Heat

Time	Present home heating costs no solar heat $/yr	Present home heating costs w/solar heat $/yr	Projected yearly savings
Present	903	496	407
In 5 yrs	1,182	649	533
In 10 yrs	1,659	911	748
In 15 yrs	2,327	1,278	1,049
Accumulated costs and savings	22,683	12,459	10,224

ESTIMATED* COST OF INSTALLING SOLAR HEATING SYSTEM: $20.00/ft² = $8000

NOTE: This system would take about 12.75 years to pay for itself.

* The cost of solar heating system is only an estimate used in this evaluation. Although the estimate should not change by much, a firm fixed price would be quoted when a solar heating installation contract is negotiated.

Solar Heating System

RECOMMENDED SYSTEM: Domestic Hot Water
COLLECTOR AREA: 100 Square Feet
ORIENTATION: Due South
STORAGE TANK SIZE: 150 gallons
STORAGE TANK LOCATION: Basement
LOCATION: Roof
TILT ANGLE: 26°

System Performance Details—Domestic Hot Water

Month	Present home heat load/mo (million Btu)	Heat supplied by recommended solar heating system (million Btu/mo)	Percent solar heat	Excess heat (for pool) (million Btu/mo)
Jan.	1.48	0.89	60	
Feb.	1.34	1.04	77	
Mar.	1.48	1.48	100	
Apr.	1.43	1.43	100	
May	1.48	1.48	100	N/A
Jun.	1.43	1.43	100	
Jul.	1.48	1.48	100	
Aug.	1.48	1.48	100	
Sep.	1.43	1.43	100	
Oct.	1.48	1.39	93	
Nov.	1.43	1.05	73	
Dec.	1.48	0.76	51	
Total	17.42	15.32	85	

PRESENT YEARLY HEATING BILL SAVINGS FOR ABOVE SYSTEM USING PRESENT ENERGY COSTS: $150/yr. 17 percent reduction in present heating costs.

Projected Yearly Heating Costs With and Without Solar Heat

Time	Present water heating costs no solar heat $/yr	Present water heating costs w/solar heat $/yr	Projected yearly savings
Present	177	27	150
In 5 yrs	232	36	196
In 10 yrs	325	47	278
In 15 yrs	456	67	389
Accumulated costs and savings	4,446	653	3,793

ESTIMATED* COST OF INSTALLING SOLAR HEATING SYSTEM: $20.00/ft² = $2000

NOTE: This system would take about 9.75 years to pay for itself.

---

* The cost of solar heating system is only an estimate used in this evaluation. Although the estimate should not change by much, a firm fixed price would be quoted when a solar heating installation

Solar Heating System for Pool

POOL SIZE: 730 Square feet area, 26,000 gallons
POOL LOCATION: Backyard, in view of sun
SOLAR COLLECTOR SIZE: 400 square feet
NOTES: Collector used for home heat. Excess in the summer time will be used to help heat pool. Heat input from a standard pool heater was not considered.
POOL COVERING: A pool cover was considered. It would be in place 12 hrs per day.

WATER TEMPERATURES IN POOL, DEGREES FAHRENHEIT

Month	No pool cover, no solar heat	No pool cover, solar heat	Pool cover solar heat	Pool cover no solar heat	Average air temp
May	65.4	66.8	71.8	69.9	66
Jun.	72	74.8	81.4	78	74
Jul.	75.3	77.7	83.2	81	79
Aug.	72.7	75.3	81.1	77.7	77
Sep.	65.3	69.1	72.5	70.2	70

TOTAL AMOUNT OF ENERGY SUPPLIED TO POOL DURING SUMMER MONTHS: 24.8 x 10^6 Btu

TOTAL AMOUNT OF ENERGY SUPPLIED TO POOL DURING WINTER MONTHS: None

ESTIMATED ENERGY COSTS FOR CONVENTIONAL POOL HEATER: Bottled Gas = $9.00/million Btu

ESTIMATED ENERGY SAVINGS PER YEAR USING SOLAR HEAT FOR POOL: $223

COMMENTS: Solar augmented pool heat with a pool cover used 12 hours per day would raise the pool water temperature by 6 degrees as compared to an unheated, uncovered pool.

CONTRACTS

Contract is one of the most effective instrumentalities of a system of private capitalistic enterprise. It is through this device that the exchange processes in modern large-scale business take place, and the vast amount of credit required in modern business is created and transferred. It is contract which makes possible the assumption and shifting of risks which inevitably are present in our highly speculative economic order. But contract in its most important aspect is a device by which persons make binding arrangements for the future or buy and sell human conduct. In this respect contract is a planning device; it is per se a most important agency of control in modern business.

In an economic society dominated by a philosophy of individualism, it is assumed that there should be relatively complete freedom of persons to make contracts. The courts accordingly enforce most contracts between persons of normal capacity, except those which in their opinion are contrary to sound social policy or have been induced by fraud or duress. The doctrine of freedom of contract assumes that there is substantial bargaining equality between all persons of sound mind and legal age. However, defensible this assumption may have been in earlier times, it is often inappropriate in a complex modern business system. Thus, legislatures have enacted many different types of legislations, particularly in the field of labor relations, restricting the doctrine of freedom of contract.

A study of contracts is a study of promises: a promise is a statement of intention, carrying assurance that the promisor (the party making the promise) will do or refrain from doing something in the future. It is a proposal of conduct. A promise must be differentiated from a representation, which is a statement of a past or present fact. A promise is a statement of what one proposes to do or not do in in the future. A statement in an insurance policy that a watchman is kept on the premises at night is merely a represnetation of fact; a statement that a watchman will be kept upon the premises is a promise.

A promise must also be distinguished from a condition. A condition is a statement of an uncertain event, present or future, upon the happening or nonhappening of which something else depends. A promise carries with it an assurance that the event will or will not happen. A condition carries no such assurance. A statement in an insurance policy that the policy is void if the insured keeps gasoline on the insured premises is a condition; a statement by the insured that he will not keep gasoline on the premises is a promise.

Essentials of a Valid Contract

In order for the contract to be enforceable, there must be:

1. an agreement -- both offer and acceptance,
2. supported by consideration,
3. entered into by parties having capacity to contract,
4. the objective of which is legal.

Types of Promises

Promises and contracts are variously classified; these classifications possess no merit other than to emphasize certain aspects of promises.

Simply stated, a contract is a binding agreement to do or to refrain from doing some lawful thing. They may be grouped:

1. as to formality -- formal or simple;
2. as to enforceability -- valid, void, voidable, or unenforceable;
3. as to compliance -- executed or executory;
4. as to reciprocal obligations - unilateral or bilateral;
5. as to intent -- express or implied.

Formal or Simple Contracts

A promise is either formal or simple; this classification emphasizes the character of the act by which a promise is made.

Formal contracts include contracts of record, contracts under seal, and negotiable instruments. A formal promise derives its binding quality from the formality with which it is expressed. A promise under seal is enforceable under the common law because of the formal document which evidences it. A sealed promise may take the form of a bond, a charter, a covenant, or a deed. Sealed instruments are known as common law specialties.

Promises in the form of bills of exchange, promissory notes, and checks are also formal. The usual rights and duties of the parties to negotiable instruments are dependent on the form in which the promise is expressed. Since the peculiar consequences attaching to negotiable instruments had their origin in the "customs of the merchants", it is usual to classify these instruments as mercantile specialties.

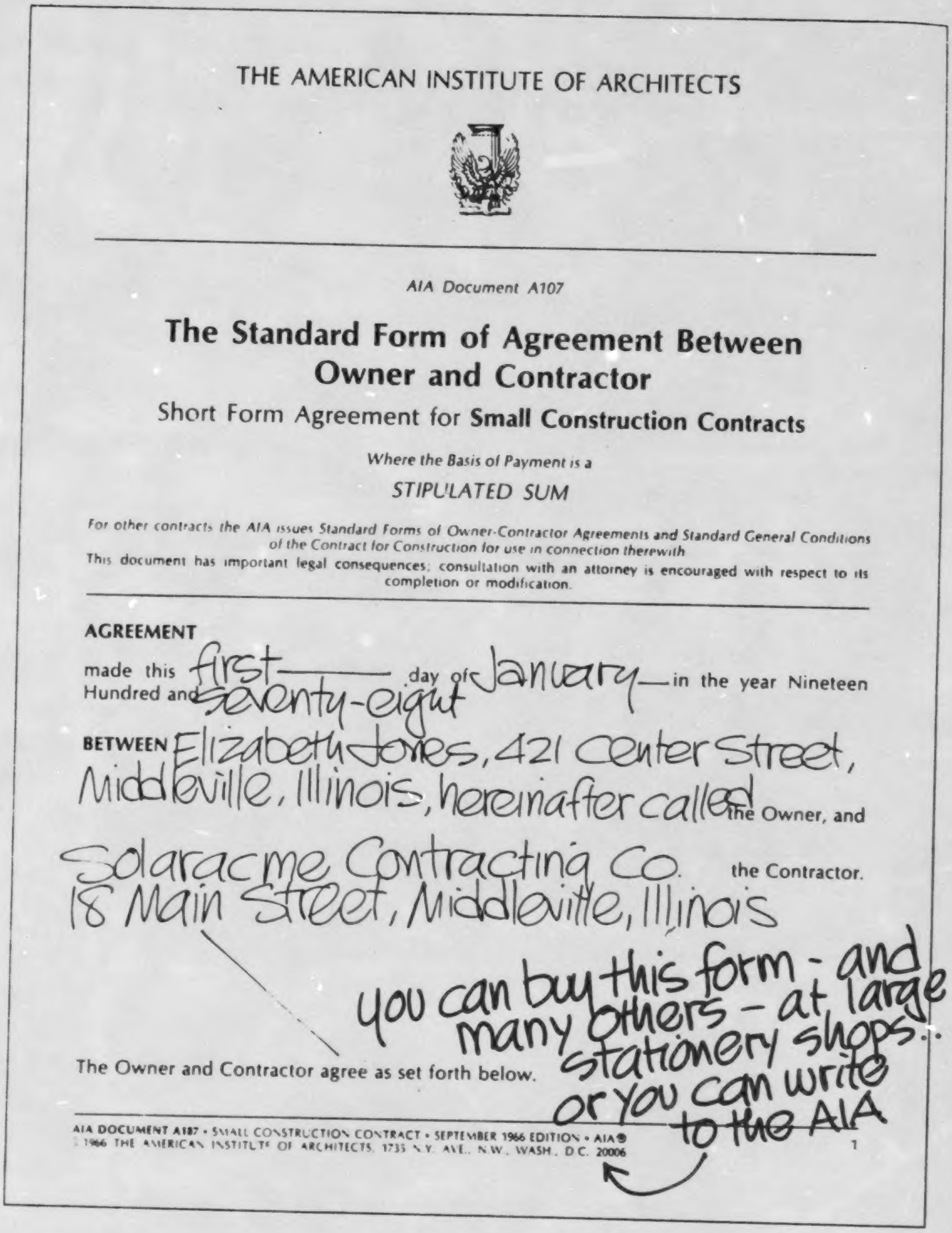
Other promises are simple. Promises not under seal and not in the form of a mercantile specialty are simple whether expressed by word of mouth or in writing.

Express or Implied Contracts

Promises are either express or implied; emphasis here is laid on the mode of proving the expression of the promise. An express promise is one in the making of which the promisor has completely set forth his promise and has left nothing to inference. An implied promise is one which is inferred from circumstances or from the conduct of the promisor. Fundamentally, of course, an express and an implied promise are the same, differing only in the manner in which they are proved.

A good way to cover the subject of construction contracts is to study an example of actual agreement forms, filled in with the terms of a fictitious agreement, and then flag some points worth mentioning. The example (see following page) is on a form developed and refined over the years by the American Institute of Architects. It's designed to be fair, favoring neither the consumer nor the contractor, and it's been tested in many, many courtrooms. The only trouble here is it's written as if an architect were involved, but that does not deter the significance of the example. After a little study, you'll see that the contract is really quite straightforward and you should be aware of the kinds of terms often written into small construction contracts.

The very act of reviewing all those terms will bring to your mind images of all the troubles others have had, troubles which led, ultimately, to the wording of the terms themselves and you will be able to decide how much protection you want to have when you take your solar step.



THE AMERICAN INSTITUTE OF ARCHITECTS

AIA Document A107

The Standard Form of Agreement Between Owner and Contractor

Short Form Agreement for **Small Construction Contracts**

Where the Basis of Payment is a

STIPULATED SUM

For other contracts the AIA issues Standard Forms of Owner-Contractor Agreements and Standard General Conditions of the Contract for Construction for use in connection therewith

This document has important legal consequences; consultation with an attorney is encouraged with respect to its completion or modification.

AGREEMENT

made this first day of January in the year Nineteen Hundred and seventy-eight

BETWEEN Elizabeth Jones, 421 Center Street, Middleville, Illinois, hereinafter called the Owner, and

Solaracme Contracting Co. the Contractor.
18 Main Street, Middleville, Illinois

you can buy this form - and many others - at large stationery shops... or you can write to the AIA

The Owner and Contractor agree as set forth below.

AIA DOCUMENT A107 • SMALL CONSTRUCTION CONTRACT • SEPTEMBER 1966 EDITION • AIA®
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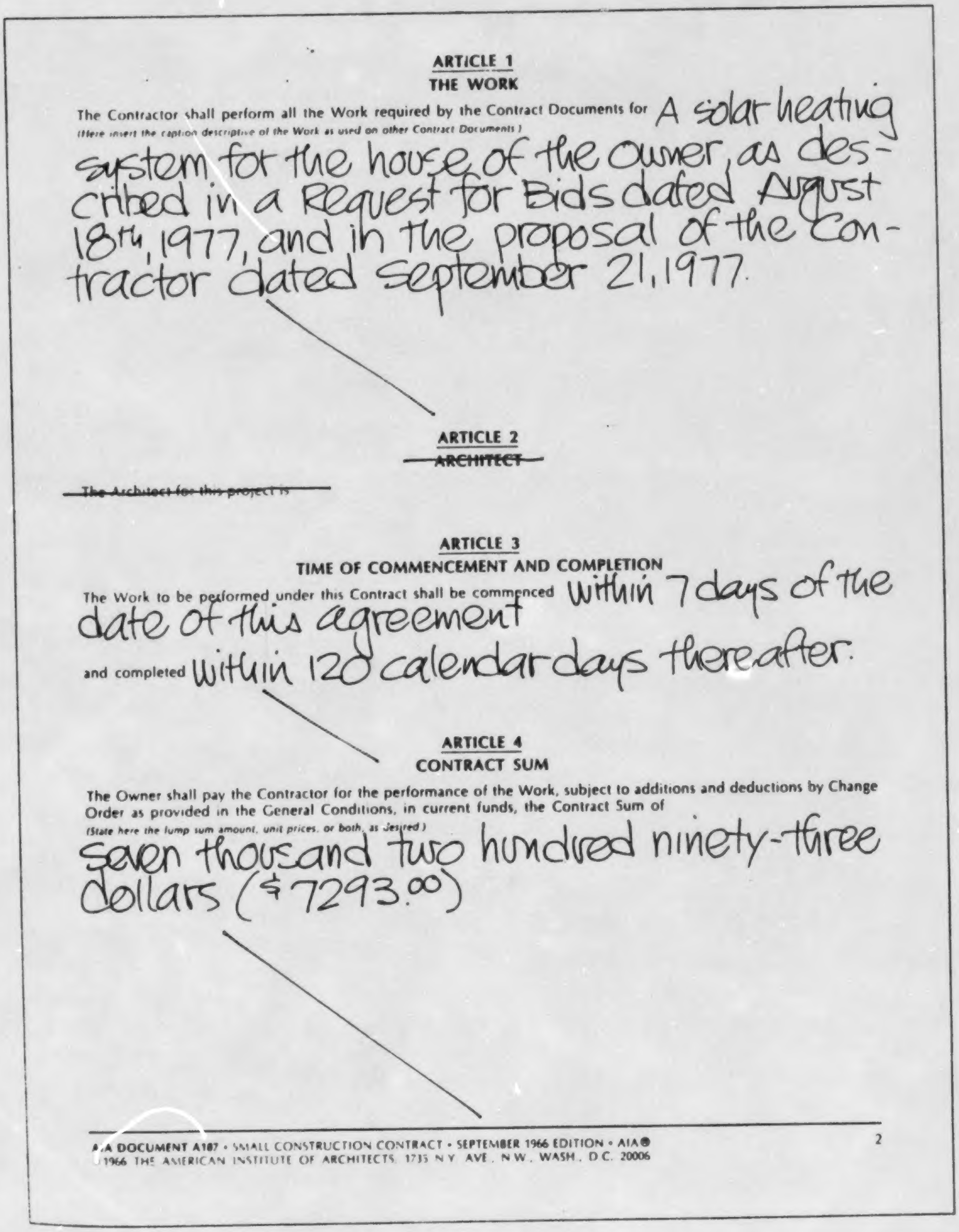

ARTICLE 1
THE WORK

The Contractor shall perform all the Work required by the Contract Documents for A solar heating
(Here insert the caption descriptive of the Work as used on other Contract Documents.)
system for the house of the Owner, as described in a Request for Bids dated August 18th, 1977, and in the proposal of the Contractor dated September 21, 1977.

ARTICLE 2
~~ARCHITECT~~

~~The Architect for this project is~~

ARTICLE 3
TIME OF COMMENCEMENT AND COMPLETION

The Work to be performed under this Contract shall be commenced within 7 days of the date of this agreement

and completed within 120 calendar days thereafter.

ARTICLE 4
CONTRACT SUM

The Owner shall pay the Contractor for the performance of the Work, subject to additions and deductions by Change Order as provided in the General Conditions, in current funds, the Contract Sum of
(State here the lump sum amount, unit prices, or both, as desired.)
seven thousand two hundred ninety-three dollars ($7293.00)

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2

ARTICLE 5
PROGRESS PAYMENTS

Based upon Applications for Payment submitted to the ~~Architect~~ owner by the Contractor ~~and Certificates for Payment issued by the Architect,~~ the Owner shall make progress payments on account of the Contract Sum to the Contractor as follows:

monthly, on or about the 5th day of each month, less 10% of each application amount, such withheld funds to be retained by the Owner until final payment.

ARTICLE 6
FINAL PAYMENT

The Owner shall make final payment fourteen days after completion of the Work, provided the Contract be then fully performed, subject to the provisions of Article 17 of the General Conditions.

ARTICLE 7
ENUMERATION OF CONTRACT DOCUMENTS

The Contract Documents are as noted in Paragraph 8.1 of the General Conditions and are enumerated as follows:
(List below the Agreement, Conditions of the Contract (General, Supplementary, and other Conditions), Drawings, Specifications, Addenda and accepted Alternates, showing page or sheet numbers in all cases and dates where applicable.)

(see Article 1)

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ARTICLE 8
CONTRACT DOCUMENTS

note:

8.1 The Contract Documents consist of this Agreement (which includes the General Conditions), ~~Supplementary and other Conditions, the Drawings~~, the Specifications, all Addenda issued prior to the execution of this Agreement, all amendments, Change Orders, ~~and written interpretations of the Contract Documents issued by the Architect~~. These form the Contract and what is required by any one shall be as binding as if required by all. The intention of the Contract Documents is to include all labor, materials, equipment and other items as provided in Paragraph 11.2 necessary for the proper execution and completion of the Work and the terms and conditions of payment therefor, and also to include all Work which may be reasonably inferable from the Contract Documents as being necessary to produce the intended results.

8.2 The Contract Documents shall be signed ~~in not less than triplicate~~ by the Owner and the Contractor. ~~If either the Owner or the Contractor do not sign the Drawings, Specifications, or any of the other Contract Documents, the Architect shall identify them~~. By executing the Contract, the Contractor represents that he has visited the site and familiarized himself with the local conditions under which the Work is to be performed.

8.3 The term Work as used in the Contract Documents includes all labor necessary to produce the construction required by the Contract Documents, and all materials and equipment incorporated or to be incorporated in such construction.

ARTICLE 9
~~ARCHITECT~~

~~**9.1** The Architect will provide general administration of the Contract and will be the Owner's representative during the construction period.~~

~~**9.2** The Architect shall at all times have access to the Work wherever it is in preparation and progress.~~

~~**9.3** The Architect will make periodic visits to the site to familiarize himself generally with the progress and quality of the Work and to determine in general if the Work is proceeding in accordance with the Contract Documents. On the basis of his on-site observations as an architect, he will keep the Owner informed of the progress of the Work, and will endeavor to guard the Owner against defects and deficiencies in the Work of the Contractor. The Architect will not be required to make exhaustive or continuous on-site inspections to check the quality or quantity of the Work. The Architect will not be responsible for construction means, methods, techniques, sequences or procedures, or for safety precautions and programs in connection with the Work, and he will not be responsible for the Contractor's failure to carry out the Work in accordance with the Contract Documents.~~

~~**9.4** Based on such observations and the Contractor's Applications for Payment, the Architect will determine the amounts owing to the Contractor and will issue Certificates for Payment in accordance with Article 17.~~

~~**9.5** The Architect will be, in the first instance, the interpreter of the requirements of the Contract Documents. He will make decisions on all claims and disputes between the Owner and the Contractor. All his decisions are subject to arbitration.~~

~~**9.6** The Architect has authority to reject Work which does not conform to the Contract Documents and to stop the Work, or any portion thereof, if necessary to insure its proper execution.~~

ARTICLE 10
OWNER

10.1 The Owner shall furnish all surveys.

10.2 The Owner shall secure and pay for easements for permanent structures or permanent changes in existing facilities.

10.3 The Owner shall issue all instructions to the Contractor ~~through the Architect~~.

ARTICLE 11
← Read this!
CONTRACTOR

11.1 The Contractor shall supervise and direct the Work, using his best skill and attention. The Contractor shall be solely responsible for all construction means, methods, techniques, sequences and procedures and for coordinating all portions of the Work under the Contract.

11.2 Unless otherwise specifically noted, the Contractor shall provide and pay for all labor, materials, equipment, tools, construction equipment and machinery, water, heat, utilities, transportation, and other facilities and services necessary for the proper execution and completion of the Work.

11.3 The Contractor shall at all times enforce strict discipline and good order among his employees, and shall not employ on the Work any unfit person or anyone not skilled in the task assigned to him.

11.4 The Contractor warrants to the Owner and the Architect that all materials and equipment incorporated in the Work will be new unless otherwise specified, and that all Work will be of good quality, free from faults and defects and in conformance with the Contract Documents. All work not so conforming to these standards may be considered defective.

11.5 The Contractor shall pay all sales, consumer, use and other similar taxes required by law and shall secure all permits, fees and licenses necessary for the execution of the Work.

11.6 The Contractor shall give all notices and comply with all laws, ordinances, rules, regulations, and orders of any public authority bearing on the performance of

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note "reasonable"

the Work, and shall notify the ~~Architect~~ owner if the ~~Drawings and~~ Specifications are at variance therewith.

11.7 The Contractor shall be responsible for the acts and omissions of all his employees and all Subcontractors, their agents and employees and all other persons performing any of the Work under a contract with the Contractor.

~~**11.8** The Contractor shall furnish all samples and shop drawings as directed for approval of the Architect for conformance with the design concept and with the information given in the Contract Documents. The Work shall be in accordance with approved samples and shop drawings.~~

11.9 The Contractor at all times shall keep the premises free from accumulation of waste materials or rubbish caused by his operations. At the completion of the Work he shall remove all his waste materials and rubbish from and about the Project as well as his tools, construction equipment, machinery and surplus materials, and shall clean all glass surfaces and shall leave the Work "broom clean" or its equivalent, except as otherwise specified.

11.10 The Contractor shall indemnify and hold harmless the Owner ~~and the Architect~~ and her agents and employees from and against all claims, damages, losses and expenses including attorneys' fees arising out of or resulting from the performance of the Work, provided that any such claim, damage, loss or expense (a) is attributable to bodily injury, sickness, disease or death, or to injury to or destruction of tangible property (other than the Work itself) including the loss of use resulting therefrom, and (b) is caused in whole or in part by any negligent act or omission of the Contractor, any Subcontractor, anyone directly or indirectly employed by any of them or anyone for whose acts any of them may be liable, regardless of whether or not it is caused in part by a party indemnified hereunder. In any and all claims against the Owner ~~or the Architect~~ or any of her agents or employees by any employee of the Contractor, any Subcontractor, anyone directly or indirectly employed by any of them or anyone for whose acts any of them may be liable, the indemnification obligation under this Paragraph 11.10 shall not be limited in any way by any limitation on the amount or type of damages, compensation or benefits payable by or for the Contractor or any Subcontractor under workmen's compensation acts, disability benefit acts or other employee benefit acts. ~~The obligations of the Contractor under this Paragraph 11.10 shall not extend to the liability of the Architect, his agents or employees arising out of (1) the preparation or approval of maps, drawings, opinions, reports, surveys, Change Orders, designs or specifications, or (2) the giving of or the failure to give directions or instructions by the Architect, his agents or employees provided such giving or failure to give is the primary cause of the injury or damage.~~

ARTICLE 12
SUBCONTRACTS

12.1 A Subcontractor is a person who has a direct contract with the Contractor to perform any of the Work at the site.

12.2 Prior to the award of the Contract the Contractor shall furnish to the ~~Architect~~ owner in writing a list of the names of Subcontractors proposed for the principal portions of the Work. The Contractor shall not employ any Subcontractor to whom ~~the Architect or~~ the Owner may have a reasonable objection. The Contractor shall not be required to employ any Subcontractor to whom he has a reasonable objection. Contracts between the Contractor and the Subcontractor shall be in accordance with the terms of this Agreement and shall include the General Conditions of this Agreement insofar as applicable.

ARTICLE 13
SEPARATE CONTRACTS

The Owner has the right to let other contracts in connection with the Work and the Contractor shall properly cooperate with any such other contractors.

ARTICLE 14
ROYALTIES AND PATENTS

The Contractor shall pay all royalties and license fees. The Contractor shall defend all suits or claims for infringement or any patent rights and shall save the Owner harmless from loss on account thereof.

ARTICLE 15
ARBITRATION

All claims or disputes arising out of this Contract or the breach thereof shall be decided by arbitration in accordance with the Construction Industry Arbitration Rules of the American Arbitration Association then obtaining unless the parties mutually agree otherwise. Notice of the demand for arbitration shall be filed in writing with the other party to the Contract and with the American Arbitration Association and shall be made within a reasonable time after the dispute has arisen.

ARTICLE 16
TIME

16.1 All time limits stated in the Contract Documents are of the essence of the Contract.

16.2 If the Contractor is delayed at any time in the progress of the Work by changes ordered in the Work, by labor disputes, fire, unusual delay in transportation, unavoidable casualties, causes beyond the Contractor's control, or by any cause which ~~the Architect may determine~~ justifies the delay, then the Contract Time shall be extended. ~~by Change Order for such reasonable time as the Architect may determine.~~

ARTICLE 17
PAYMENTS

17.1 Payments shall be made as provided in Article 5 of this Agreement.

17.2 Payments may be withheld on account of (1) defective Work not remedied, (2) claims filed, (3) failure of the Contractor to make payments properly to Subcontractors or for labor, materials, or equipment, (4) damage to another contractor, or (5) unsatisfactory prosecution of the Work by the Contractor.

17.3 Final payment shall not be due until the Contractor has delivered to the Owner a complete release of all liens arising out of this Contract or receipts in full ☆

think about this one

covering all labor, materials and equipment for which a lien could be filed, or a bond satisfactory to the Owner indemnifying him against any lien.

17.4 The making of final payment shall constitute a waiver of all claims by the Owner except those arising from (1) unsettled liens, (2) faulty or defective Work appearing after Substantial Completion, (3) failure of the Work to comply with the requirements of the Contract Documents, or (4) terms of any special guarantees required by the Contract Documents. The acceptance of final payment shall constitute a waiver of all claims by the Contractor except those previously made in writing and still unsettled.

ARTICLE 18

PROTECTION OF PERSONS AND PROPERTY

The Contractor shall be responsible for initiating, maintaining, and supervising all safety precautions and programs in connection with the Work. He shall take all reasonable precautions for the safety of, and shall provide all reasonable protection to prevent damage, injury or loss to (1) all employees on the Work and other persons who may be affected thereby, (2) all the Work and all materials and equipment to be incorporated therein, and (3) other property at the site or adjacent thereto. He shall comply with all applicable laws, ordinances, rules, regulations and orders of any public authority having jurisdiction for the safety of persons or property or to protect them from damage, injury or loss. All damage or loss to any property caused in whole or in part by the Contractor, any Subcontractor, any Sub-subcontractor or anyone directly or indirectly employed by any of them, or by anyone for whose acts any of them may be liable, shall be remedied by the Contractor, except damage or loss attributable to faulty ~~Drawings or~~ Specifications or to the acts or omissions of the Owner ~~or Architect~~ or anyone employed ~~by either of~~ her or for whose acts ~~either of~~ she may be liable but which are not attributable to the fault or negligence of the Contractor.

ARTICLE 19

CONTRACTOR'S LIABILITY INSURANCE

The Contractor shall purchase and maintain such insurance as will protect him from claims under workmen's compensation acts and other employee benefit acts, from claims for damages because of bodily injury, including death, and from claims for damages to property which may arise out of or result from the Contractor's operations under this Contract, whether such operations be by himself or by any Subcontractor or anyone directly or indirectly employed by any of them. This insurance shall be written for not less than any limits of liability specified as part of this Contract, or required by law, whichever is the greater, and shall include contractual liability insurance as applicable to the Contractor's obligations under Paragraph 11.10. Certificates of such insurance shall be filed with the Owner.

ARTICLE 20

OWNER'S LIABILITY INSURANCE

The Owner shall be responsible for purchasing and maintaining his own liability insurance and, at his option, may maintain such insurance as will protect him against claims which may arise from operations under the Contract.

ARTICLE 21

PROPERTY INSURANCE

21.1 Unless otherwise provided, the Owner shall purchase and maintain property insurance upon the entire Work at the site to the full insurable value thereof. This insurance shall include the interests of the Owner, the Contractor, Subcontractors and Sub-subcontractors in the Work and shall insure against the perils of Fire, Extended Coverage, Vandalism and Malicious Mischief.

21.2 Any insured loss is to be adjusted with the Owner and made payable to the Owner as trustee for the insureds, as their interests may appear, subject to the requirements of any mortgagee clause.

21.3 The Owner shall file a copy of all policies with the Contractor prior to the commencement of the Work.

21.4 The Owner and Contractor waive all rights against each other for damages caused by fire or other perils to the extent covered by insurance provided under this paragraph. The Contractor shall require similar waivers by Subcontractors and Sub-subcontractors.

ARTICLE 22

CHANGES IN THE WORK

22.1 The Owner without invalidating the Contract may order Changes in the Work consisting of additions, deletions, or modifications, the Contract Sum and the Contract Time being adjusted accordingly. All such Changes in the Work shall be authorized by written Change Order signed by the Owner. ~~or the Architect as his duly authorized agent~~.

22.2 The Contract Sum and the Contract Time may be changed only by Change Order.

22.3 The cost or credit to the Owner from a Change in the Work shall be determined by mutual agreement before executing the Work involved.

ARTICLE 23

CORRECTION OF WORK

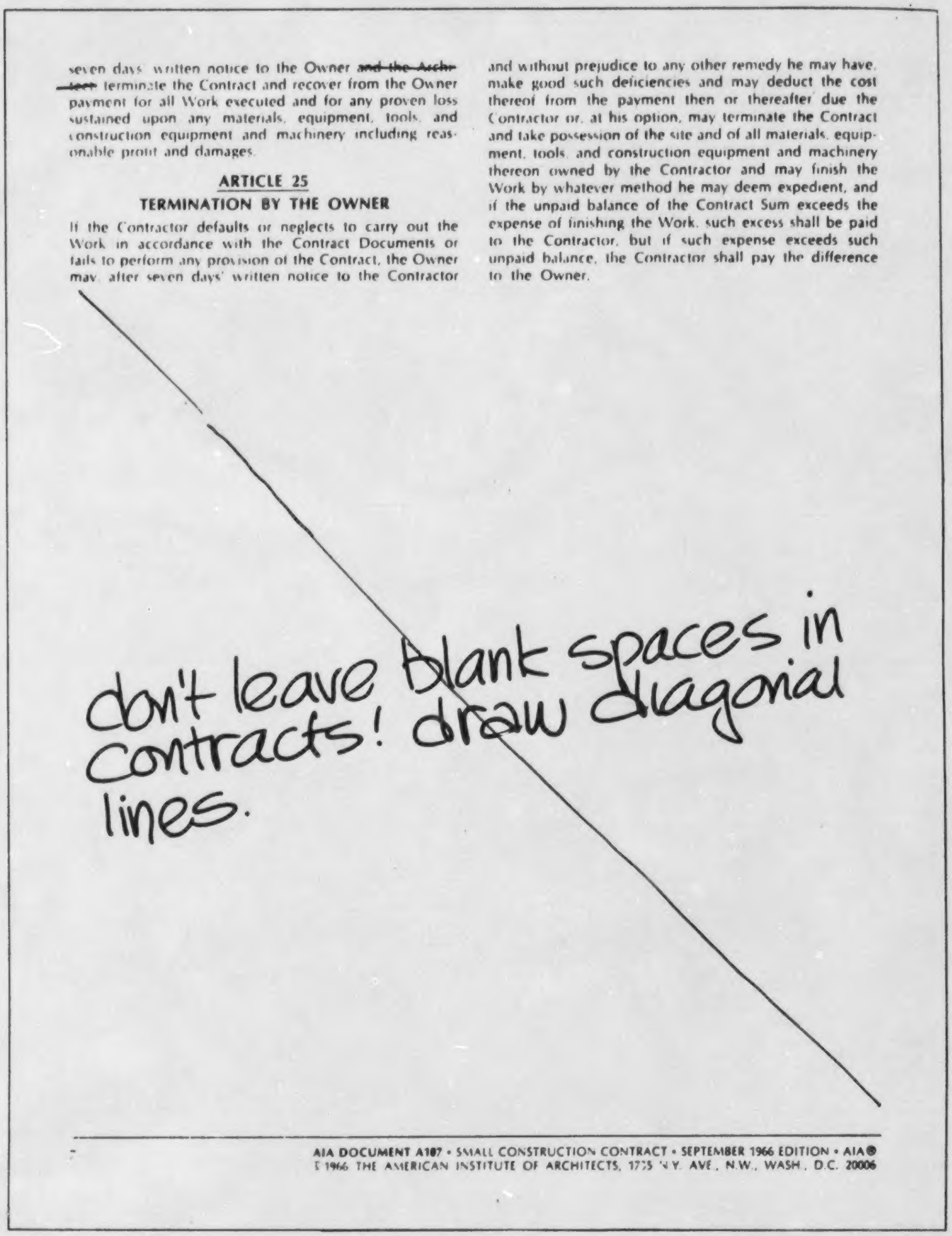
The Contractor shall correct any Work that fails to conform to the requirements of the Contract Documents where such failure to conform appears during the progress of the Work, and shall remedy any defects due to faulty materials, equipment or workmanship which appear within a period of one year from the Date of ~~Substantial~~ Completion of the Contract or within such longer period of time as may be prescribed by law or by the terms of any applicable special guarantee required by the Contract Documents. The provisions of this Article 23 apply to Work done by Subcontractors as well as to Work done by direct employees of the Contractor.

you might want to expand on this article and name specific remedies

ARTICLE 24

TERMINATION BY THE CONTRACTOR

If ~~the Architect fails to issue a Certificate of Payment for a period of thirty days through no fault of the Contractor, or if~~ the Owner fails to make payment thereon for a period of thirty days, the Contractor may, upon



seven days' written notice to the Owner ~~and the Architect~~ terminate the Contract and recover from the Owner payment for all Work executed and for any proven loss sustained upon any materials, equipment, tools, and construction equipment and machinery including reasonable profit and damages.

ARTICLE 25
TERMINATION BY THE OWNER

If the Contractor defaults or neglects to carry out the Work in accordance with the Contract Documents or fails to perform any provision of the Contract, the Owner may, after seven days' written notice to the Contractor and without prejudice to any other remedy he may have, make good such deficiencies and may deduct the cost thereof from the payment then or thereafter due the Contractor or, at his option, may terminate the Contract and take possession of the site and of all materials, equipment, tools, and construction equipment and machinery thereon owned by the Contractor and may finish the Work by whatever method he may deem expedient, and if the unpaid balance of the Contract Sum exceeds the expense of finishing the Work, such excess shall be paid to the Contractor, but if such expense exceeds such unpaid balance, the Contractor shall pay the difference to the Owner.

don't leave blank spaces in contracts! draw diagonal lines.

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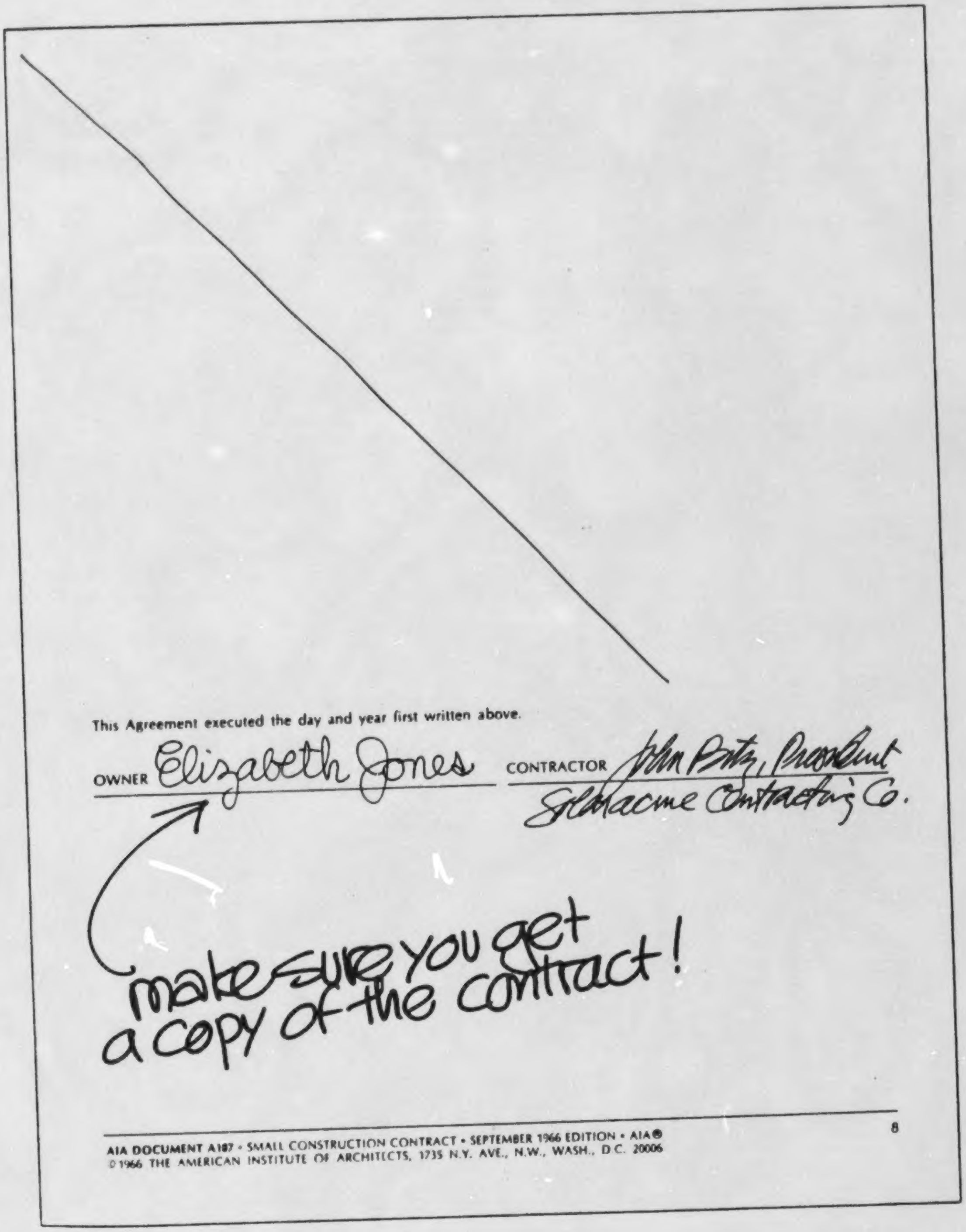

This Agreement executed the day and year first written above.

OWNER Elizabeth Jones

CONTRACTOR John Bitz, President
Goldacme Contracting Co.

make sure you get
a copy of the contract!

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The example contract on the following pages utilizes an actual agreement form for a construction contract, filled in with the terms of a fictitious agreement, along with some point flagged as worth mentioning.

Remember, it's a lot better to think about all these things now (at the time of preparing the written contract) than to think about them for the first time when something suddenly goes wrong.

Here's a sample contractor's agreement...

Poor identification of owner; no identification of contractor!

We propose to furnish and install a Solaracme Heating system
at 421 Center Street, Middleville, Ill
in accordance with the following conditions and specifications:

EQUIPMENT

Solaracme collector - air - 420 sq. ft.
Solaracme blower
Solaracme control system
insulated rock chamber
Solaracme collector - liquid - 38 sq. ft.
insulated 80 gallon storage tank

LOCATION OF EQUIPMENT

1. Suitable space and access for this installation is to be provided by you.

This can lead to big extras if it's discovered later that a beam is in the way.

DUCT WORK

1. Ductwork to be installed by us will be designated, fabricated and installed in accordance with American Society of Heating, Refrigerating and Air Conditioning Engineers standards, within the limits of existing installation conditions.

Too loose.

RESPONSIBILITY

The following responsibilities will be assumed by you or us as indicated:

Delivery, uncrating, erection	US	Wiring from Panel to Conditioner	YOU
Equipment Foundation	US	Cutting holes	US
Ductwork (as described,	US	Patching	US
Duct Insulation	US	Redecorating	YOU
Supply Outlets	US	Plumbing within	US
Return Grilles	US	Pipe Insulation	US
Adequate Electric Service	YOU		

Watch out for these!

Who are us?
Who am you?

IX-S-359

PLUMBING Heat exchanger for domest. h. w.
All pipe and fittings copper.

WIRING As required.

Pretty weak; watch out!

MISCELLANEOUS

We will conform to the requirements of your Request for Bids letter of August 18, 1977.

Good! This can really protect you if you wrote the request carefully.

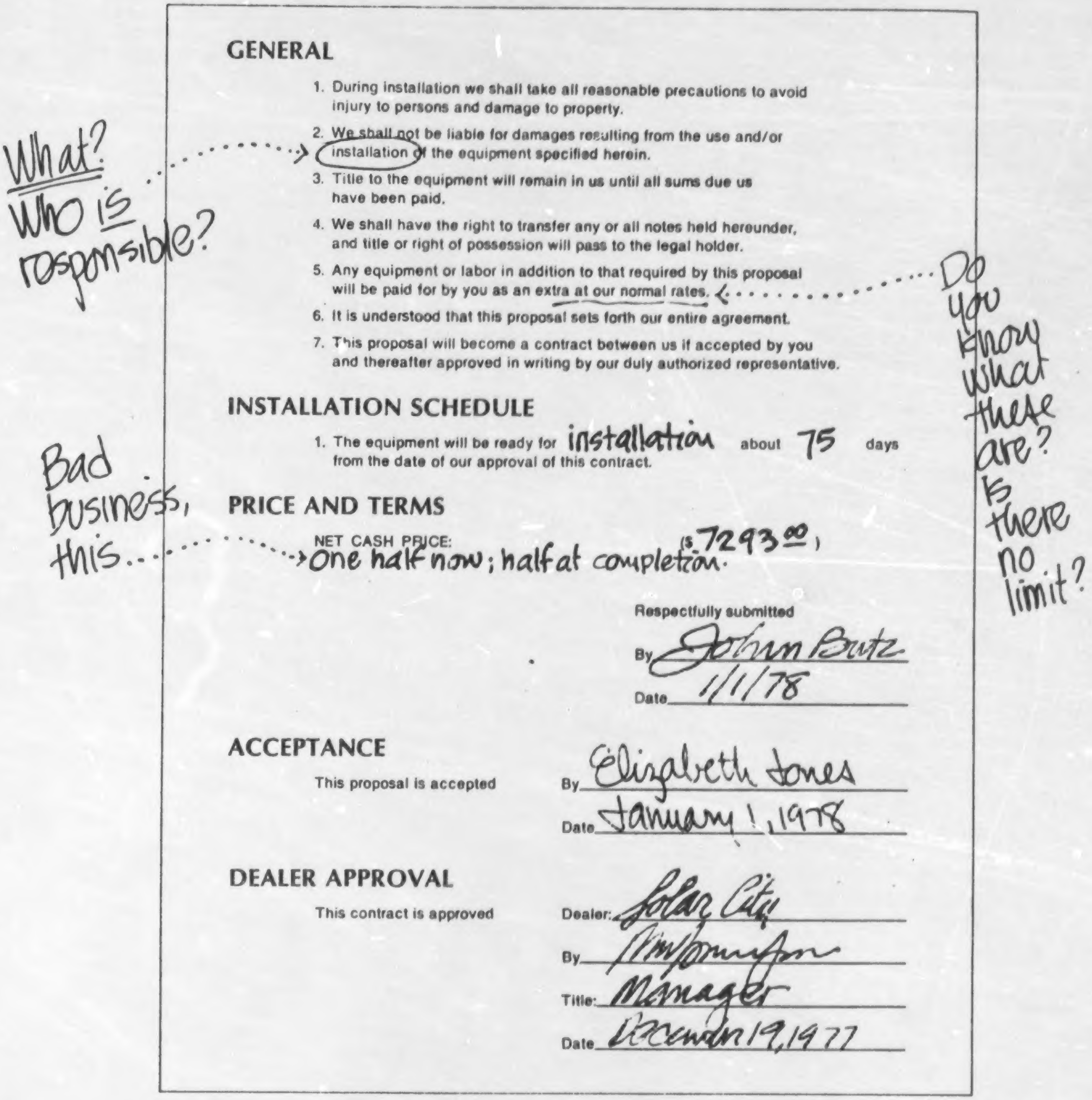
WORKMANSHIP

1. Our work will be performed in the highest workmanlike manner and will comply with existing governing codes and regulations.

WARRANTY AND SERVICE

1. After installation a qualified representative will start, test, and provide instructions on the use of the equipment.
2. All equipment, material and labor furnished by us will bear a one year warranty from date of installation against defects in workmanship and material. In addition, the collectors, controls and heat exchanger are protected in accordance with the Solaracme Five Year Protection Plan.
3. Service under this warranty, except for emergency calls, will only be provided during normal working hours and does not include filter or fuse replacement.

Where is this little gem described?



GENERAL

1. During installation we shall take all reasonable precautions to avoid injury to persons and damage to property.
2. We shall not be liable for damages resulting from the use and/or installation of the equipment specified herein.
3. Title to the equipment will remain in us until all sums due us have been paid.
4. We shall have the right to transfer any or all notes held hereunder, and title or right of possession will pass to the legal holder.
5. Any equipment or labor in addition to that required by this proposal will be paid for by you as an extra at our normal rates.
6. It is understood that this proposal sets forth our entire agreement.
7. This proposal will become a contract between us if accepted by you and thereafter approved in writing by our duly authorized representative.

What? Who is responsible?

Do you know what these are? Is there no limit?

INSTALLATION SCHEDULE

1. The equipment will be ready for installation about 75 days from the date of our approval of this contract.

PRICE AND TERMS

NET CASH PRICE: $7293.00,
One half now; half at completion.

Bad business, this...

Respectfully submitted

By John Butz

Date 1/1/78

ACCEPTANCE

This proposal is accepted

By Elizabeth Jones

Date January 1, 1978

DEALER APPROVAL

This contract is approved

Dealer: Solar City

By

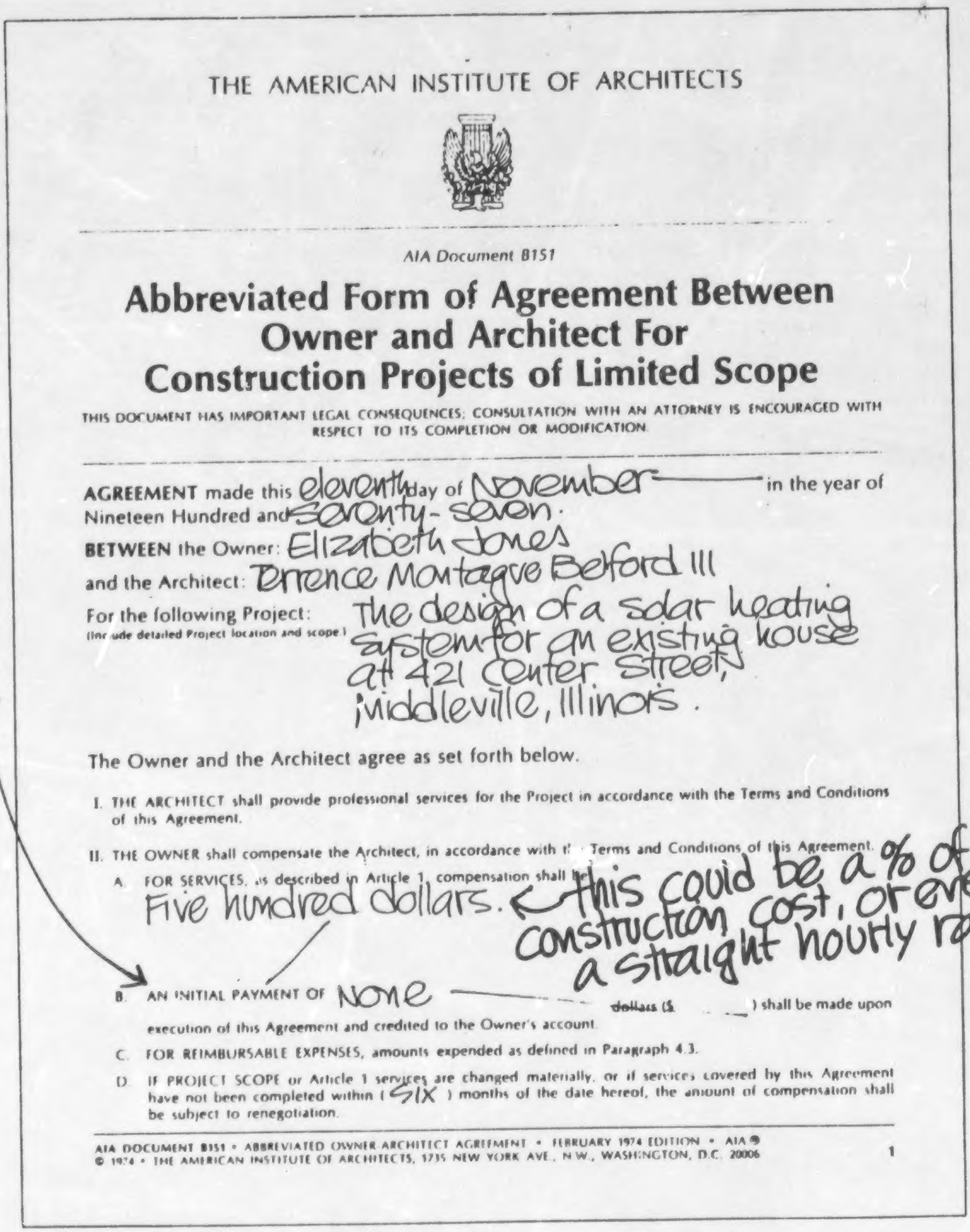
Title: Manager

Date December 19, 1977

Should an architect be involved in the solarizing of an existing building? Not unless he has great interest and experience in the subject, and the building owner feels incapable of handling the job himself.

Architects are not equipment designers; in fact, most states forbid architects to practice any kind of engineering. If the need for professional help is in the design of solar hardware, see a mechanical engineer; but if the need is for design help related to the space, the appearance, or the finishes of a building, consult an architect. And, if the project is large enough to justify it, hire an architect and have him in turn engage--under his basic fee--the engineers needed to handle those basic specialties--structural, mechanical, electrical--traditionally outside the architect's own specialties. One principal attribute of the architect is construction experience--materials, workmanship, expansion, contraction, time, weather, contractors, contracts.

The contract on the following pages is an example of an agreement between a consumer and an architect--compare this with the previous examples and you can evaluate what all the options are.



THE AMERICAN INSTITUTE OF ARCHITECTS

AIA Document B151

Abbreviated Form of Agreement Between Owner and Architect For Construction Projects of Limited Scope

THIS DOCUMENT HAS IMPORTANT LEGAL CONSEQUENCES; CONSULTATION WITH AN ATTORNEY IS ENCOURAGED WITH RESPECT TO ITS COMPLETION OR MODIFICATION.

AGREEMENT made this eleventh day of November in the year of Nineteen Hundred and Seventy-seven.

BETWEEN the Owner: Elizabeth Jones

and the Architect: Terrence Montague Belford III

For the following Project: The design of a solar heating system for an existing house at 421 Center Street, Middleville, Illinois.

(Include detailed Project location and scope.)

The Owner and the Architect agree as set forth below.

I. THE ARCHITECT shall provide professional services for the Project in accordance with the Terms and Conditions of this Agreement.

II. THE OWNER shall compensate the Architect, in accordance with the Terms and Conditions of this Agreement.

A. FOR SERVICES, as described in Article 1, compensation shall be

Five hundred dollars. ← this could be a % of the construction cost, or even a straight hourly rate

this is not always necessary.

B. AN INITIAL PAYMENT OF None ~~dollars~~ ($) shall be made upon execution of this Agreement and credited to the Owner's account.

C. FOR REIMBURSABLE EXPENSES, amounts expended as defined in Paragraph 4.3.

D. IF PROJECT SCOPE or Article 1 services are changed materially, or if services covered by this Agreement have not been completed within (six) months of the date hereof, the amount of compensation shall be subject to renegotiation.

AIA DOCUMENT B151 • ABBREVIATED OWNER-ARCHITECT AGREEMENT • FEBRUARY 1974 EDITION • AIA®

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because of this "normal" it's especially important to mention the solar nature of the project on p.1

TERMS AND CONDITIONS OF AGREEMENT BETWEEN OWNER AND ARCHITECT

ARTICLE 1

ARCHITECT'S SERVICES

The Architect's Services consist of the four phases described below and include normal structural, mechanical and electrical engineering services and any other services included in Article 11 as related to a single Stipulated Sum Construction Contract. The extent of the Architect's duties and responsibilities and the limitations of his authority as assigned hereunder shall not be modified without his written consent.

DESIGN PHASE

1.1 The Architect shall prepare Design Studies consisting of drawings and other documents for approval by the Owner, and shall submit to the Owner a Statement of Probable Construction Cost.

CONSTRUCTION DOCUMENTS PHASE

1.2 The Architect shall prepare from the approved Design Studies, Drawings and Specifications setting forth in detail the requirements for the Project, and shall submit an adjusted Statement of Probable Construction Cost.

1.2.1 The Architect shall assist the Owner in filing the required documents for the approval of governmental authorities having jurisdiction over the Project.

note: this is not the preparation of such documents

BIDDING OR NEGOTIATION PHASE

1.3 The Architect, following the Owner's approval of the Construction Documents and of the adjusted Statement of Probable Construction Cost, shall assist the Owner in obtaining bids and in awarding the Construction Contract.

CONSTRUCTION PHASE

1.4 The Construction Phase will commence with the award of the Construction Contract and will terminate when the final Certificate for Payment is issued to the Owner.

1.4.1 The Architect shall provide general Administration of the Construction Contract, as set forth below.

1.4.2 All of the Owner's instructions to the Contractor shall be issued through the Architect. The Architect shall prepare all Change Orders.

1.4.3 The Architect shall make periodic visits to the site to familiarize himself generally with the progress and quality of the Work and to determine in general if the Work is proceeding in accordance with the Contract Documents. On the basis of his on-site observations as an architect, he shall endeavor to guard the Owner against defects and deficiencies in the Work of the Contractor. The Architect shall not be required to make exhaustive or continuous on-site inspections to check the quality or quantity of the Work. The Architect shall not be responsible for construction means, methods, techniques, sequences or procedures, or for safety precautions and programs in connection with the Work, and he shall not be responsible for the Contractor's failure to carry out the Work in accordance with the Contract Documents.

1.4.4 Based on such observations at the site and on the Contractor's Applications for Payment, the Architect shall determine the amount owing to the Contractor and shall issue Certificates for Payment in such amounts. The issuance of a Certificate for Payment shall constitute a representation by the Architect to the Owner, based on the Architect's observations at the site as provided in Subparagraph 1.4.3 and the data comprising the Application for Payment, that the Work has progressed to the point indicated, that to the best of the Architect's knowledge, information and belief, the quality of the Work is in accordance with the Contract Documents (subject to an evaluation of the Work for conformance with the Contract Documents upon Substantial Completion, to the results of any subsequent tests required by the Contract Documents, to minor deviations from the Contract Documents correctable prior to completion, and to any specific qualifications stated in the Certificate for Payment), and that the Contractor is entitled to payment in the amount certified. By issuing a Certificate for Payment, the Architect shall not be deemed to represent that he has made any examination to ascertain how and for what purpose the Contractor has used the moneys paid on account of the Contract Sum.

1.4.5 The Architect shall be the interpreter of the requirements of the Contract Documents and the impartial judge of performance thereunder by both the Owner and Contractor, and shall make decisions on all claims of the Owner and Contractor relating thereto.

1.4.6 The Architect shall review and approve shop drawings, samples, and other submissions of the Contractor only for conformance with the design concept of the Project and for compliance with the information given in the Contract Documents.

1.4.7 The Architect shall conduct inspections to determine the Dates of Substantial Completion and final completion, and shall issue a final Certificate for Payment.

1.4.8 The Architect shall not be responsible for the acts or omissions of the Contractor, or any Subcontractors, or their agents or employees, or any other persons performing any of the Work.

ARTICLE 2

THE OWNER'S RESPONSIBILITIES

2.1 The Owner shall provide full information, including a complete program, regarding his requirements for the Project.

this is a detailed list of your needs for the project.

2.2 The Owner shall furnish full information about and affecting the site, including a certified land survey, and when deemed necessary by the Architect, soil test reports or the services of a soil engineer.

2.3 The Owner shall furnish laboratory tests, inspections, and reports as required by law or the Contract Documents.

2.4 The Owner shall furnish such legal, accounting and insurance counseling services necessary for the Project, and such auditing services as he may require to ascertain how the Contractor has used the money paid to him.

2.5 The information, surveys, and reports required by Paragraphs 2.1 through 2.4 inclusive shall be furnished at the Owner's expense, and the Architect shall be entitled to rely upon the accuracy and completeness thereof.

2.6 If the Owner becomes aware of any fault or defect in the Project or nonconformance with the Contract Documents, he shall give prompt written notice to the Architect.

2.7 The Owner shall furnish information required of him as expeditiously as necessary for the orderly progress of the Work.

ARTICLE 3

Read! →

CONSTRUCTION COST

3.1 The Construction Cost shall be the total cost or estimated cost to the Owner of all Work designed or specified by the Architect, which shall be determined as follows, with precedence in the order listed:

3.1.1 For completed construction, the cost of all such Work, including the cost of labor, materials and equipment furnished by the Owner and the cost of managing construction, or

3.1.2 For Work not constructed, (1) the lowest bona fide bid received from a qualified bidder for any or all of such Work, or (2) if the Work is not bid, the bona fide negotiated proposal submitted for any or all of such Work, or

3.1.3 For Work or portions of the Work for which no such bid or proposal is received, the latest Statement of Probable Construction Cost.

3.2 Construction Cost does not include the compensation of the Architect and his consultants, the cost of the land, right-of-way, or other costs which are the responsibility of the Owner in Paragraphs 2.1 through 2.4 inclusive.

3.3 The Architect cannot and does not guarantee that bids will not vary from Statements of Probable Construction Cost or other cost estimates prepared by him.

3.4 When a fixed limit of Construction Cost is established as a condition of this Agreement, it shall be in writing signed by the parties and shall include a bidding contingency of ten percent, and if it is exceeded by the lowest bona fide bid or negotiated proposal, the Owner shall (1) give written approval of an increase in such fixed limit, (2) authorize rebidding the Project within a reasonable time, or (3) cooperate in revising the Project to reduce the Probable Construction Cost. In the case of (3) the Architect, without additional charge, shall discharge his responsibility by modifying the Drawings and Specifications, and having done so, shall be entitled to compensation in accordance with this Agreement.

ARTICLE 4

PAYMENTS TO THE ARCHITECT

here's your protection!

4.1 An initial payment as set forth in Paragraph 8 is the minimum payment under this Agreement.

4.2 Payments for Services shall be made monthly, in proportion to services performed. If compensation is on the basis of a fixed fee or percentage of construction cost it shall, at the completion of each Phase, equal the following percentages of the total Compensation:

Design Phase	35%
Construction Documents Phase	75%
Bidding or Negotiation Phase	80%
Construction Phase	100%

4.3 Payment for Reimbursable Expenses shall be made monthly. Reimbursable Expenses are in addition to compensation and include actual expenditures made by the Architect for the Project for: travel and subsistence; long distance calls; fees paid to governmental authorities; renderings and models required by the Owner; Owner authorized overtime, reproductions, postage and handling of Drawings and Specifications, excluding duplicate sets at the completion of each Phase for the Owner's review and approval.

4.4 No deductions shall be made from the Architect's compensation on account of sums withheld from payments to contractors.

4.5 If the Project is suspended for more than three months or abandoned in whole or in part, the Architect shall be paid for services performed prior to receipt of such notice from the Owner together with all termination expenses. If the Project is resumed after being suspended for more than three months, the Architect's compensation shall be subject to renegotiation.

4.6 Payments due the Architect under this Agreement shall bear interest at the legal rate commencing sixty days after date of billing.

ARTICLE 5

TERMINATION OF AGREEMENT

5.1 This Agreement may be terminated by either party upon seven days written notice should the other party fail substantially to perform in accordance with its terms through no fault of the party initiating the termination. In the event of termination due to the fault of parties other than the Architect, the Architect shall be paid his compensation for services performed to termination date, including Reimbursable Expenses, plus termination expenses.

5.2 Termination expenses are defined as Reimbursable Expenses directly attributable to termination, plus an amount computed as a percentage of the total compensation earned to the time of termination as follows:

this is sometimes reduced on small projects (see Art. 11)

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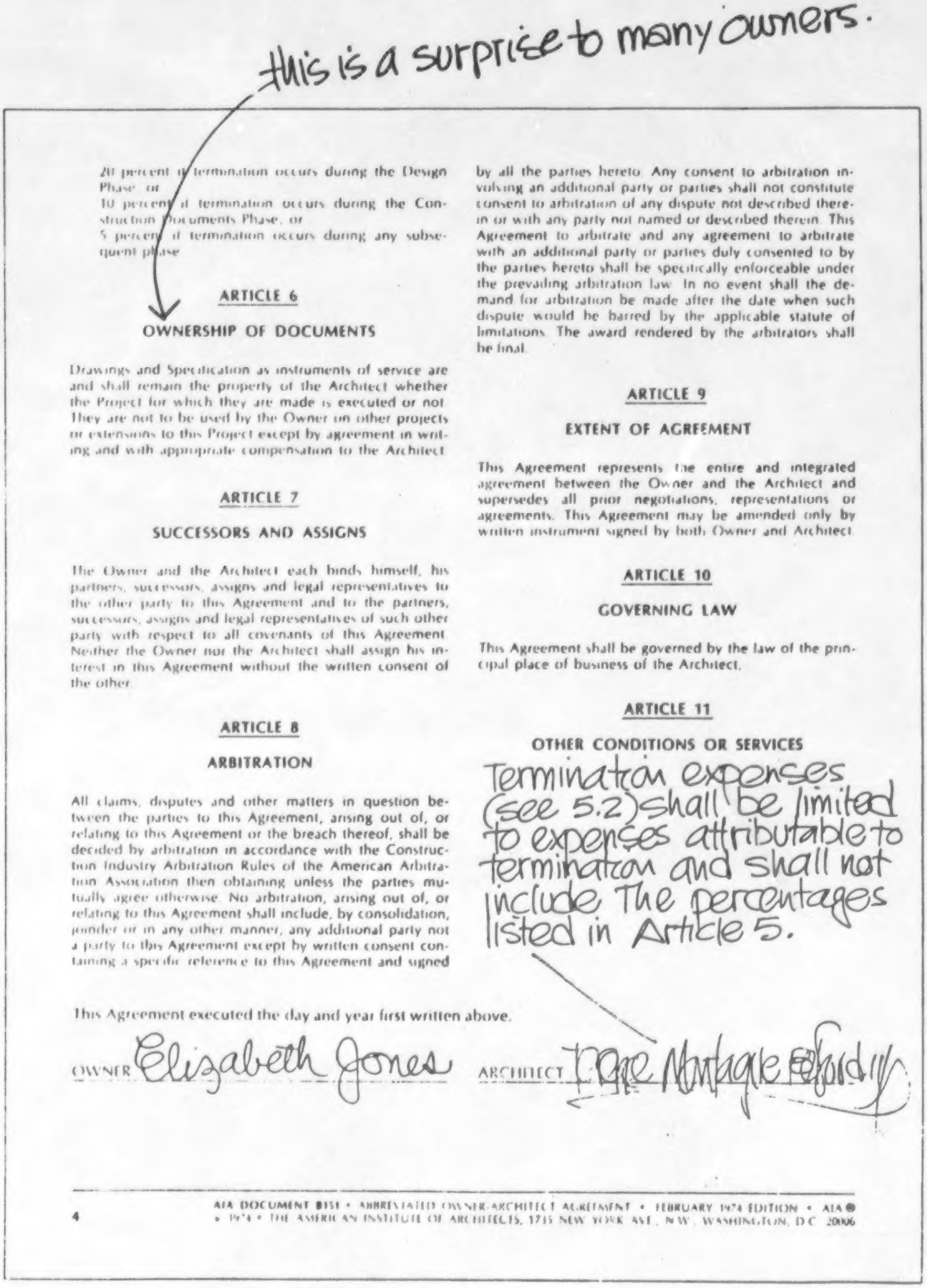

this is a surprise to many owners.

20 percent if termination occurs during the Design Phase, or
10 percent if termination occurs during the Construction Documents Phase, or
5 percent if termination occurs during any subsequent phase

ARTICLE 6

OWNERSHIP OF DOCUMENTS

Drawings and Specification as instruments of service are and shall remain the property of the Architect whether the Project for which they are made is executed or not. They are not to be used by the Owner on other projects or extensions to this Project except by agreement in writing and with appropriate compensation to the Architect.

ARTICLE 7

SUCCESSORS AND ASSIGNS

The Owner and the Architect each binds himself, his partners, successors, assigns and legal representatives to the other party to this Agreement and to the partners, successors, assigns and legal representatives of such other party with respect to all covenants of this Agreement. Neither the Owner nor the Architect shall assign his interest in this Agreement without the written consent of the other.

ARTICLE 8

ARBITRATION

All claims, disputes and other matters in question between the parties to this Agreement, arising out of, or relating to this Agreement or the breach thereof, shall be decided by arbitration in accordance with the Construction Industry Arbitration Rules of the American Arbitration Association then obtaining unless the parties mutually agree otherwise. No arbitration, arising out of, or relating to this Agreement shall include, by consolidation, joinder or in any other manner, any additional party not a party to this Agreement except by written consent containing a specific reference to this Agreement and signed by all the parties hereto. Any consent to arbitration involving an additional party or parties shall not constitute consent to arbitration of any dispute not described therein or with any party not named or described therein. This Agreement to arbitrate and any agreement to arbitrate with an additional party or parties duly consented to by the parties hereto shall be specifically enforceable under the prevailing arbitration law. In no event shall the demand for arbitration be made after the date when such dispute would be barred by the applicable statute of limitations. The award rendered by the arbitrators shall be final.

ARTICLE 9

EXTENT OF AGREEMENT

This Agreement represents the entire and integrated agreement between the Owner and the Architect and supersedes all prior negotiations, representations or agreements. This Agreement may be amended only by written instrument signed by both Owner and Architect.

ARTICLE 10

GOVERNING LAW

This Agreement shall be governed by the law of the principal place of business of the Architect.

ARTICLE 11

OTHER CONDITIONS OR SERVICES

Termination expenses (see 5.2) shall be limited to expenses attributable to termination and shall not include the percentages listed in Article 5.

This Agreement executed the day and year first written above.

OWNER Elizabeth Jones ARCHITECT [illegible] Montague [illegible]

Unilateral or Bilateral Contracts

Promises are either bilateral or unilateral; this is a fundamental distinction and one which possesses practical importance.

A bilateral promise is one which contemplates a promise in exchange for it. Thus, A promises to convey Blackacre to B for $5000 if B will promise to pay $5000 for the conveyance. A's promise is a bilateral promise because it calls for a promise from B. If B makes the promise asked for, his is also a bilateral promise because it is given in exchange for a promise.

A unilateral promise is one which is given in exchange not for a promise, but for an act. A promises B $25 if B will repair A's automobile; A's promise is unilateral because it calls for an act. The resulting transaction is one in which there is a promise only on one side. In a bilateral transaction, there is a promise on each side.

The terms in question also are frequently employed to describe offers; a bilateral offer is one which calls for a promise; a unilateral offer is either an offer of an act for a promise or an offer of a promise for an act.

Whether a given promise is bilateral, calling for a promise in exchange, or unilateral, calling for an act, is a question of fact. When the parties make their intent clear, as they may by the proper choice of language, courts have no alternative but to honor that intent. In doubtful cases, however, the courts are inclined to say that a given promise is bilateral rather than unilateral. As a practical matter, business agreements almost universally are based upon bilateral promises.

Enforceability of Contracts

Promises, according to a common classification, are void, voidable, or valid.

A void promise is one which courts refuse to enforce. Courts will not, for instance, enforce a promise to commit a crime.

A valid promise is a normal promise to which courts attach normal consequences.

A voidable promise is one made under such circumstances that its maker enjoys the privilege of escaping liability under it. It is a promise, however, which courts will enforce unless the promisor exercises his privilege to avoid it. The promise of an infant is an illustration of a voidable promise.

Liens

A lien is the right given by law to a creditor to have a debt or charge satisfied out of the property belonging to the debtor. A lien may entitle the holder (lienor) to have the realty sold whether or not the owner desires it. A lien necessarily arises from the relation of debtor and creditor, and, although the creation of that relation may have been voluntary, the enforcement is wholly free of the owner's consent or agreement.

The right of a creditor to have his debt satisfied has its origin, under common law, in the use of personal property. In early times, liens generally were recognized after time, effort, or goods had been expended by laborers, mechanics, or materialmen in the repairing or financing of another individual's personal property. The right to a lien, under common law, carried with it the right to "bond" or possess the personal property until the lien was satisfied. In fact, if possession of the property was surrendered, the lien was deemed discharged, or legally lost. Indeed, in such instances, possession was more than nine-tenths of the law.

The theory of possession was so strongly entrenched under common law that even the earliest and most obvious liens on real property--those supported by mortgage debts--were not recognized as liens, unless title and possession were transferred to the lienor or creditor. This mortgage lien theory, although modified as to possession and control, is still adhered to in the mortgage "title" states, where the use of the mortgage deed is mandatory.

The lien laws affecting real property, as practiced today, have their origin in statutory provisions enacted by each state in the Union. Under these laws, liens against real property are enforceable in one form or another, even though possession, control, or title remains with the debtor, until physical and legal disposition of the property is made by the court.

Liens are of two types: specific and general.

A general lien affects all the property of the debtor. A specific lien affects only a certain piece or pieces of property.

The following liens are of the specific type:
1. Mortgages
2. Taxes, assessments, and water charges
3. Mechanic's liens
4. Vendee's liens
5. Vendor's liens
6. Surety bail bond liens
7. Attachments

General liens include:
1. Judgments (state and federal)
2. Decedent's debts
3. Inheritance tax liens (state and federal)
4. Corporation franchise tax liens.

Mechanic's Liens

The mechanic's lien is purely statutory, having no origin in common law or equity. It may be defined as a security claim given by statute to those who perform labor or furnish material in the improvement of real property. Predicated on the principle of unjust enrichment, laws have been enacted by the various state legislatures recognizing the claims of materialmen and laborers against the property to which they have added value. This right to a mechanic's lien is in addition to the right or action against the person who made the contract of employment or purchase. The lien is specific, as it affects only the property benefited and is governed by the provisions of the statute under which the right is obtained. The entire subject of mechanic's liens is highly technical; the laws vary materially in the different states; and everyone dealing with alterations or improvements to real estate should secure from an attorney in his own community legal advice as to his rights and obligations.

Filing a Mechanic's lien. Mechanic's liens may be filed by a contractor, subcontractor, laborer, or materialman. The notice of lien must be filed during progress of the work and the furnishing of the materials or within a specified period (generally three months) after completion of the contract, final performance of the work, or final furnishing of materials. A mechanic's lien is usually asserted through the filing of a notice of the claim with the county clerk. This notice must be under oath of the lienor or his agent and must set forth the claim in detail and substantially in form as follows:

Claim of Lien

STATE OF ....
COUNTY OF ....

Before me, the undersigned authority, personally appeared ...., who being duly sworn, says that he is the lienor herein [or (agent) (attorney) of the lienor herein] .... whose address is .... and that in pursuance of a contract with ...., lienor furnished labor, services, or materials consisting of .... on the following described real property in .... County, of .... State, owned by ....of a total value of $........... of which there remains unpaid $.......... and furnished the first of the same on .... 19..., and the last of the same on .... 19..., and (if the lien is claimed by one not in privity—direct contact—with the owner) that the lienor served his notice of claim to ownEr on .... 19..., by ....

Sworn to and subscribed before me this .... day of .... 19 .

....
Notary Public
My Commission expires

In many states, in order to perfect the right to a mechanic's lien claim, the statutory regulations provide for the recording of a notice of commencement of contract work with the clerk of records and for the posting of a certified copy thereof on the premises. Such notice identifies the parties involved, the property affected, and the work to be performed. Where such constructive notice is mandatory, work, that is, the improvements described, must be commenced within a stipulated time (generally thirty days); otherwise such notice is void and of no legal consequence.

The right to file a mechanic's lien is given not only to the contractor dealing directly with the owner of the property, but also to the subcontractors. In Massachusetts, Pennsylvania, and several other states, the owner's property can be held for materials and labor supplied by a subcontractor in accordance with the provisions of the original contract. The law imposes upon the owner the obligation of seeing that the subcontractors are being paid by the general contractor, in order to avoid liens upon his property and additional costs for the work performed. In most states the law is that the subcontractor is entitled to a lien on the property by virtue of his subrogation to the rights of the contractor-in-chief. Subcontractors under this rule can hold the owner's property only for the amount due under the main contract--the one to which the owner is a party. If however, the main contract calls for installment payments--that is, payments at certain periods or at certain stages of the work--and the owner anticipates these payments, he may be held by subcontractors for the amount so anticipated. They can rely on his making payments only according to schedule, and he deviates therefrom at his peril. Owners may also be held for payment of work done on their property with their consent and approval, either expressed or implied, even though the contract for the work was made by some other person, such as a tenant. The owner is not liable, however, for work done by a tenant without his knowledge or consent, nor is a remainderman usually liable for work done by a life tenant, and in such cases liens cannot be enforced against the owner's or remainderman's property.

In New York State, orders on payment (assignments of money due) are often encountered in connection with building loan mortgages. Although not creating a lien when filed, they nevertheless should not be ignored. Because a mechanic's lien, subsequently filed, might be superior to all advances made after the filing of the order, the lender is wise to insist that it first be satisfied and discharged of record.

Protection Against False Claims. To protect the owner from false claims by subcontractors with whom the owner is factually or legally not "in privity", statutory requirements make it mandatory for such lienors to serve a notice on the owner either before commencing the furnishing of services or delivery of materials or within a specified time (thirty to forty five days in most jurisdictions). To further safeguard the owner against claims of liens subsequent to meeting specified contract payments, the owner, as a rule, has the right to withhold the final payment (10 percent or more of the contract price) and to require the general contractor to furnish an affidavit stating that all subcontractors, laborers, and materialmen have been paid in full. The furnishing of such affidavit is generally a prerequisite to the institution of any suit to enforce a claim of lien. Unless enforced as noted below, liens expire after a lapse of one year, unless renewed for a further period by court order. The filing of the lien gives notice of it to all dealing with the property, and is good against all except those whose rights are prior as shown by the public records. The lien is not affected by unrecorded instruments and takes precedence over a deed or mortgage given prior to, but not recorded until after, the filing of the lien.

A mechanic's lien is enforced by foreclosure. The foreclosure is a legal action against the owner and those whose claims against the property are inferior to the lienor's. A judgment of the court in favor of the lienor orders the sale of the property by an officer of the court, the payment into court of the moneys realized at such sale, a marshaling of those claims against the property that have been affected by the foreclosure, and a payment of the claims in their proper order.

The right to file a lien is an important one to mechanics and materialmen. They can ascertain the ownership of the property from the public records and can also find the amount of mortgages or the liens against it. This information assists them in determining whether or not to extend credit to the owner of the property. With due care, losses through bad debts can be kept to a minimum. Some states give greater protection to mechanic's lien claimants than others. Most states, however, follow a middle road, favoring neither the mechanic's lien claimant nor the mortgagee. In states such as Illinois, Maine, and Massachusetts, where mechanic's liens are offered the greatest protection, objections may be raised on the grounds that such stringent laws discourage building operations, especially those of a speculative kind. New buildings are often financed by means of building loan mortgages. It is reasonable to assume that mortgagees will not be attracted to the building loan market should they find that the law protects the mechanic's lienor to the mortgagee's detriment.

The filing of mechanic's liens against a building in course of construction may or may not be an indication of the inability of the owner to meet his obligations, because frequently contractors and materialmen file liens for protection against the possibility that other claims may arise during the course of construction. The important thing for all persons interested in the operation is to get the building finished. It is then capable of producing an income and is more readily salable.

Building loan mortgages are advancedfrom time to time during construction, and in some states (New York, for example) advances made by a mortgagee before mechanic's liens are filed are prior in lien to the claims of those who performed the work and furnished the materials. Cessation of work on the building often results in a foreclosure of the building loan mortgage and a consequent loss to the contractors.

Rights of Lienors and Others. The construction of a new building, or the making of any other improvement to real property, causes to arise certain legal rights and duties of the parties involved. The principal parties are the owner, the contractor, and the mortgagee. All of these rights and duties are clearly defined by the statutes of the several states and should be familiar to the parties or to those who act for them. The owner (or the one in possession, ordering the work, as in the case of work done for a tenant) must see that he lives up to the provisions of the contract, especially those concerning payments, and must take notice of subcontractor's claims when legally brought to his attention. He must ascertain the provisions of law regarding any money he receives from mortgages, some laws being very specific in disposing of his duty toward such moneys. The laws of several states provide that all moneys advanced to the owner are trust funds that will be used exclusively for the payment of contractors and materialmen. The contractor, that is, the one who does the work or furnishes the material, should safeguard his rights by complying with the statute should it be necessary to file a notice of his lien. He must also recognize the rights of other lienors and the duty, or advantage it may be to him, of acting in conjunction with them for the protection of all. The law may provide that the job may be taken over and finished by the lienors, in view of the advantage of such action to all in interest. Mortgagees must exercise care that all papers in connection with their loans are properly prepared and filed, that advances are made during the course of construction in accordance with the agreement for the loan, and that careful attention is given to all actual and constructive notices of mechanic's liens. One intent of a mechanic's lien law is to compel, as far as possible, the application of mortgage money to the payment of the cost of the improvement for which it was advanced.

Discharge of Mechanic's Lien. A mechanic's lien in most states may be discharged or become noneffective as follows:

1. By payment, and by a certificate or satisfaction piece executed and acknowledged by the lienor and duly filed in the county clerk's office.

2. By expiration, which occurs after the lapse of a certain period of time, generally one or two years after filing, unless an action to foreclose it or an action to foreclose a mortgage on the property has been begun within that period.

3. By an order of the court vacating or canceling the lien for neglect to prosecute it. This order may be obtained by service of notice by the owner on the lienor requiring the lienor to commence an action to foreclose the lien within a specified time, not less than thirty days. The claim of the lienor may be disputed by the owner, and he may take this course in order that the claim may be tried in court, or the lien canceled. If the courst order is obtained, the record of the lien will be marked "Discharged by Order of the Court".

4. By filing of a bond approved by the court. The bond may be that of two or more personal sureties or of a surety company. The record of the lien is marked "Discharged by Bond", the property is freed from the lien, and the lienor has recourse to the bond.

5. By deposit of money into court. Before an action is commenced on a lien, the amount claimed with interest to date of deposit may be deposited with the county clerk. After an action has been commenced, the amount deposited shall be such a sum as in the judgment of the court will cover the amount of any judgment that may be recovered in the action. The lien is marked "Discharged by Payment".

Other Specific Liens

Vendee's Lien. When the seller (vendor) defaults, the purchaser (vendee) has a lien for the money paid under the contract of sale. The lien also extends to sums spent by the purchaser in improving the premises but does not include the cost of title examination. For that reason this item is often made a lien by the terms of the contract. Being an equitable lien, it is enforceable by foreclosure.

Vendor's Lien. A vendor's lien is also an equitable lien, one of the first to be recognized by most states. It arises when the seller conveys a piece of real property to the purchaser and does not receive the entire purchase price at that time. The seller has a lien for the unpaid balance. Foreclosure is the means of enforcing the lien, but such remedy is in addition to those that the seller may have at law.

Attachments. Another form of lien on real property is the attachment, which is a statutory privilege given to a plaintiff or complainant in the courts in an action for money damages before any judgment is procured. In some states every plaintiff in every action may file an attachment against the defendant's property. Most states, however, give the plaintiff this privilege only for specific cause: generally for the nonresidence of the defendant, or his removal, or threatened removal, of property from the state, or for his obtaining credit on the basis of a false financial statement made in writing. By filing an attachment, the plaintiff in the action virtually insures himself that there will be some property out of which the judgment could be paid if the action is successful.

In order to protect the defendant, the plaintiff obtaining the writ of attachment must file a bond in writing that if the defendant wins, the plaintiff will pay all costs and damages that the defendant may suffer because of the attachment.

An attachment, once file, lasts until the action has been disposed of. If the plaintiff wins, the lien of attachment is discharged. If the defendant against whom the attachment lien has been filed wishes to sell his property during the pendency of the action, he may file a bond equal in amount to the plaintiff's demand, plus costs. The county clerk would then mark the attachment lien "Discharged by Bond".

General Liens

Corporation Franchise Tax. In most states every corporation is taxed annually on its franchise, or right to do business in the state. There are various methods of computing the amount of the tax. It is usually based on the amount of capital, or capital stock, or net income of the corporation. The tax is a general lien on the property of the corporation and can be enforced against it.

Judgments. A judgment is the determination of the rights of parties through an action at law. It may originate in either state or federal courts. Not all judgments are money judgments, but only those that give a money award are considered here. Judgments for the payment of money, when properly docketed, become general liens on all property of the debtor. The judgment docket is the book or register kept by the county clerk in which is entered a record of all judgments of which the clerk has been furnished with a transcript. The docket is arranged alphabetically according to debtors. When a search is made for liens against a property, it is important to examine the judgment docket to see if there are any judgments against those who now own, or for a certain time prior have owned, the property.

A judgment is enforced by execution and by the sale of any property of the debtor that may be found. Execution is a writ directed to the sheriff, the executive officer of the court. This writ authorizes him to seize the debtor's property and to sell so much of it as may be required to pay the judgment plus incidental expenses. The property may be real or personal. If there is real property apparently owned by the debtor, the sheriff, after legal advertising, offers to the highest bidder all of the debtor's right, title, and interest of, in and to the property. This interest may be substantial or it may be nominal, or even nothing at all. The buyer at such a sale ascertains this at his own risk before making a bid. What is of interest in this discussion is that the judgment is a lien on the debtor's real property and that such property may be sold against his will by an officer of the court.

A judgment, as a lien on property, attaches in some states when rendered, in others when recorded or docketed, and in still others upon issuance of the writ of execution. The lien attaches to all land held by the defendance and remains in effect for a statutory period of time, generally about ten years after the date when the judgment is perfected. Under certain circumstances the lien may be renewed, but we seldom find this done. If the debtor pays a judgment, he is entitled to a formal receipt called a satisfaction piece. This satisfaction piece is filed with the county clerk, who, upon its receipt, marks "Satisfied" against the record of the judgment on the docket. Many judgments, after being obtained in a lower court, are reversed on appeal to a higher court. Pending the appeal the debtor may file a bond, approved by the court, in order to free his property from the lien of the judgment. The judgment in such a case is marked "Suspended on Appeal". Judgments obtained in any federal court, as a rule, must be docketed in the county wherein the real estate is situated in order to effectuate the lien of the judgment thereon.

Priority of Liens

The usual rule as to priority of liens is that they rank in the order of their filing or recording in the office of the proper officials. A mortgage recorded yesterday has precedence over one recorded today, and both are prior in lien to a mechanic's lien that may be filed tomorrow, unless by its terms the mortgage is made subordinate thereto. In many states, however, there is no priority as among mechanic's lienors, even though the liens have been filed at various times during the course of construction. As to judgments, there is an exception to the rule of priority liens: a judgment is not good against the rights of those claiming under a deed or mortgage actually delivered before the date of docket of the judgment, even though the deed or mortgage has not been recorded. The reason for this exception is that the recording laws protect innocent purchasers and mortgagees for value, and such, it may be presumed, are those who hold the deeds and mortgages. They parted with value when the deed or mortgage was delivered to them, and they relied upon the record title in doing so. The same would be true of a purchaser who had a contract to buy but had not yet received his deed. The creditor who secures a judgment does so regardless of what a debtor may or may not own; he asserts an existing claim in an action at law, and when he secures his judgment it becomes a lien on what the debtor actually owns at that time. It must of course be recognized that deeds and mortgages given or contracts entered into to defraud creditors may be set aside and that reference is here made only to those given in good faith for value. It must also be noted that the lien of all taxes and assessments imposed by any governmental authority is superior to every other lien regardless of the date of the lien or its recording. Of course, the relative rank of any two or more liens can be changed by agreement between the holders of them.

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